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APTITUDE-TREATMENT INTERACTIONS BETWEEN STUDENT STUDY BEHAVIOUR AND TWO HIGH SCHOOL SCIENCE TEACHING METHODS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Aptitude-Treatment Interactions between Student Study Behaviour and Two High School Science Teaching Methods" submitted by John Murray Richmond in partial fulfilment of the requirements for the degree of Master of Education.

Abstract

The preferential model for aptitude-treatment interactions suggests that an instructional treatment should be designed to exploit a student's preferred aptitudes. Interactions between aptitudes and treatments should occur when students are placed in an environment where, for some, their particular study behavior aptitudes are matched, and for others, they are mismatched with important characteristics of the treatment.

The present study is concerned with testing this paradigm. In addition, an attempt is made to determine whether the study behavior aptitudes that lead to ATI are more likely to be unidimensional or multidimensional in nature. Grade ten and eleven biology and chemistry students from two different Edmonton Public senior high schools participated in the study. These were selected as representative of two different instructional approaches. Students in the grade 11 biology classes at the two schools formed the sample (n = 148) used to test the ATI model.

A STUDY BEHAVIOR QUESTIONNAIRE was developed to test the students' study behavior aptitudes. Scores on this test were used as measures of the students' aptitudes. The instructional treatment was applied to the students for a complete five month semester. The criterion measure was a common Biology 20 test administered at the end of the semester.

Q technique or inverse factor analysis was used to define additional student study behavior aptitudes.

Correlations were run between SCAT verbal and quantitative abilities, study behavior aptitudes, and the Q aptitudes. The student study behavior aptitudes were found to be generally uncorrelated with sex, SCAT abilities, and performance.

Analyses of variance revealed a significant difference in student academic performance due to SCAT quantitative ability. A significant difference due to treatments was noted in two cases. Three interaction effects involving student study behavior aptitudes were found. These indicated differential student performance under the treatments caused by differences in Internal-External and Dependence study behavior aptitudes combined with SCAT ability.

No evidence was found to support the idea that Q technique defined aptitudes which were important for detecting ATI.

The present study was exploratory. However some implications for future research into ATI have been suggested.

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Chapter I

Introduction

Individualizing instruction is a process which has captured the imagination of an unusually large and diverse group of educators and educational psychologists. There are two primary objectives for this procedure. The first is to optimally match instructional strategies with student capabilities so that the outcome is maximal student learning. The second is to maximize learning in both the cognitive and affective domains of the individual student.

One strategy of individualizing instruction is referred to as the aptitude-treatment interaction or ATI (Cronbach and Gleser, 1965; Cronbach and Snow, 1969). The ATI offers one explanation why the search for a single most effective method of instruction appears to have been futile (Stolurow, 1965; Snow, 1970). When an interaction between a treatment and some aptitude occurs, clearly optimum learning in all students cannot take place under a global instructional treatment: the interaction means that some students are maximizing performance under one treatment and different students are maximizing under another. The construct of ATI is appealing, yet in spite of the numerous research efforts which have attempted to find ATI, researchers have had little success in demonstrating stable and replicable instances of the phenomenon (Cronbach and Snow, 1969; Bracht, 1970).

According to Cronbach and Snow (1969) the lack of success in finding replicable instances of ATI is a consequence of inappropriate types of experimental design and inadequate data analysis. Salomon (1971) partially attributes these shortcomings to the absence of "conceptual tools ... developed so that specific ATI's can be either theoretically interpreted or deduced from a rationale (p. 1)." In particular, it would appear that the "aptitude" has to bear some clear relationship to the quality of the treatment (Cronbach, 1967). It seems apparent then that further investigation would proceed from a well-founded theory and methodology concerned with discovering instances of ATI.

Significance of the Study

Despite the rather discouraging evidence to date, at least two reasons for continuing ATI research may be stated. Firstly, ATI research provides a response to the current public demand for accountability in the educational system. Quite clearly, the public is asking that educators develop programs which will enable each child to achieve his potential, regardless of economic, ethnic, social, cultural or genetic background. The educational system is being held responsible for failures and dropouts. It has been suggested that each child with his unique grouping of individual differences be offered a program which will stimulate learning and development. The rationale for such an approach suggests that different techniques will result in similar learning behaviours through the aptitude-treatment interaction process. In other words,

there is a general belief that there are alternative routes to good learning and this belief is sufficiently strong to warrant further search for reliable instances of ATI.

A second reason for continuing ATI research is the possibility that we can better understand, diagnose and predict individual difficulties and potentials. If students can be offered a truly individualized instruction, we must examine interactions among personality characteristics, cognitive abilities and the entire instructional environment with the intention of developing rigorous and comprehensive theories of instruction.

Although there are good reasons for carrying out further ATI research, it also appears that some critical rethinking of the general issue is necessary. Two problems are outstanding. First, a theoretical framework for ATI is required, especially one that helps the educator designate aptitudes suitable for the ATI paradigm. The second problem is the development of analytical techniques aimed at detecting ATI.

Outline of the Study

This study is an investigation of the occurrence of aptitude-treatment interactions between students' study behaviour aptitudes and two methods of high school biology teaching. It is based on a preferential model (Snow, 1970) which hypothesized that certain instructional approaches may be able to capitalize on an individual learner's preferred style of processing information. The aptitude is assumed to be a unidimensional or multidimensional study behavioural or

affective style. The basic assumption for ATI is that different methods of instruction will differentially benefit different students. Which treatment will benefit a particular individual can only be predicted from a knowledge of each student's aptitude pattern.

This study begins with the investigation of a number of the students' study behavior aptitudes which are sampled by means of the STUDY BEHAVIOR QUESTIONNAIRE, High School Version (hereafter designated the SBQH). A series of three-way fixed effects analyses of variance are then employed to test for the presence of interactions using Schools, SBQH subscale scores, and SCAT scores as independent variables and performance scores on a common Biology 20 test as the criterion variable. Q technique or inverse factor analysis (Cattell, 1966) is then employed to determine whether additional criteria for grouping the students can be selected from among items on the SBQH. The analysis of variance procedures are used next to test for interactions using the "Q-subscales" as independent variables together with the SCAT scores.

Thesis Organization

Chapter two of this study discusses the various aspects of the problem as conceptualized in this investigation. It includes the purpose of the study, a definition of terms, hypotheses and delimitations of the study and a review of the research literature pertinent to the problem. Chapter three deals with the research procedures used. Chapter four contains the results of the study and Chapter five discusses findings and implications for further research.

Chapter 2

The Problem

Definitions of Terms Used

The definition of an interaction used in this study is that given by Cronbach and Snow (1970). They state that "An interaction is present when an effect found for one kind of subject or in one kind of setting is not found under other conditions (p. 3)." As an illustration, assume that two groups of students are subjected to two different instructional techniques. The high alphas, group one, are found to perform best under technique A. Students from the second group, the high betas, do their best under treatment B. In addition it is determined that the alphas do rather poorly under treatment B while the betas perform in a similar manner when instructed under technique A. The results of the experiment might appear as illustrated in Figure 1.

There are two kinds of interactions which can be distinguished. Figure 1 is an illustration of a strong disordinal interaction. Here the two treatments do not have the same rank order for each type of student. To be most effective, the type of treatment which is given a student is not prescribed until the student is diagnosed as either an alpha or a beta. This is the kind of interaction which this study is explicitly concerned with detecting.

Ordinal interactions can be identified graphically by

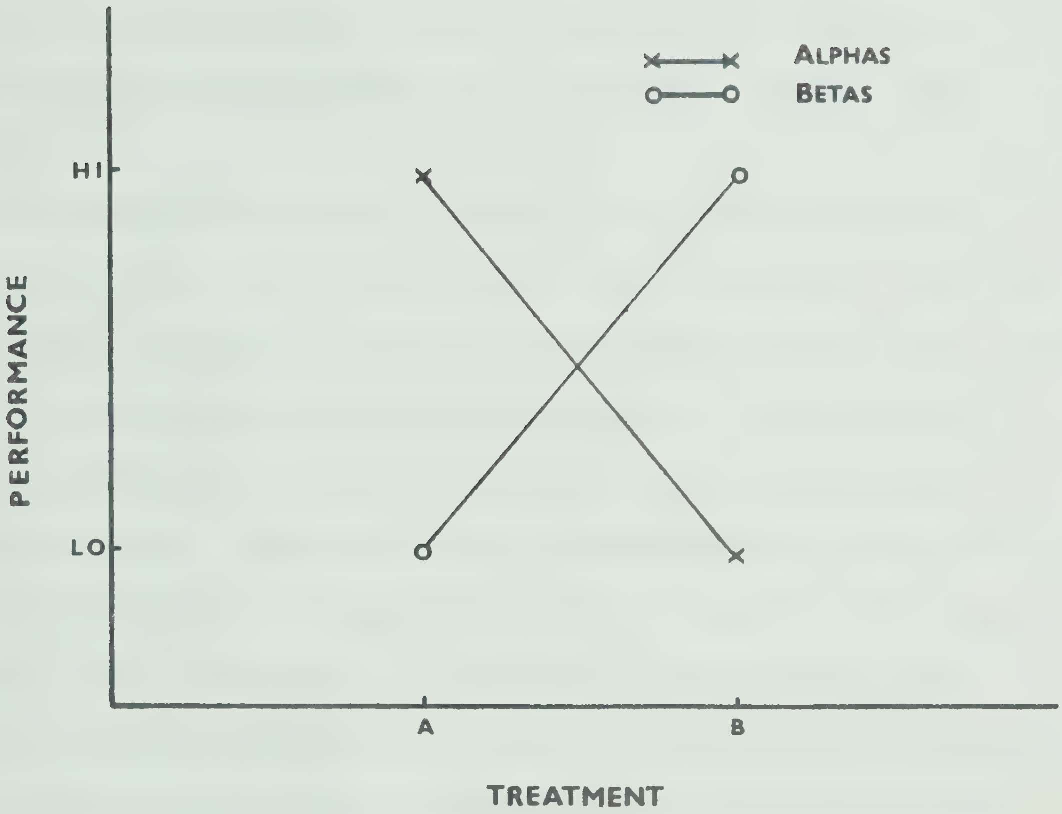

Figure 1 Illustration of ATI

the fact that the lines representing student performance on the treatments, although not parallel, never cross each other within the range of the experiment. One of the treatments is consistently better for both groups of students, although not to the same extent. Under these conditions, differential assignment of students according to aptitudes is impossible. Both the alphas and the betas will do better under a particular treatment.

A treatment is broadly defined to be any manipulation performed on a student in an instructional context. For this study the two different teaching approaches used at the control and experimental schools become the treatments. Individual variations in the application of the treatment within each school are specifically excluded from consideration.

An aptitude is defined "as any characteristic of the individual that increases (or impairs) his probability of success in a given treatment (Cronbach and Snow, 1969 p. 7)." In this study the student's aptitude is determined by his score(s) on particular items or combinations of items of the SBQH

Review of Related Literature

Conceptual Frameworks for ATI

Salomon (1971), building on the work of Snow (1969), suggests three conceptual frameworks for investigating ATI. The Remedial Approach is the most common. Here task specific capabilities are assumed to interact with alternative

instructional treatments. A student who is deficient in a particular capability is given more time, repetitions, or a different presentation of the material in order to achieve the teaching objective. This approach is roughly that taken by Gagné (1970), and suggested by Bloom in mastery learning (Bloom, Hastings, and Madaus, 1971). Major limitations of this approach are that the aptitude is always highly task specific and the modifications in treatment are rather minor under the restrictions of a highly specific instructional objective.

The Compensatory Model attempts to "compensate for each learner's deficiency by providing the mode of presentation that the learner can not provide for himself (Snow, 1970, p. 76)." Under the model, the effects of a specific disability are minimized without changing the deficiency itself. A common point between this approach and the remedial one is that both tend to benefit students with particular learning problems. Applying the treatments to other students either does not improve their performance (which leads to ordinal interaction) or actually inhibits their performance (which leads to a disordinal interaction). Usually, however, the interactions found under both Remedial and Compensatory models are of the ordinal type. The treatment has the effect of increasing the performance of the students who are experiencing difficulty relative to those who are performing adequately. It is unusual that the group undergoing treatment actually surpasses the performance of the ordinary group. These

models then are not very useful for making differential assignment of students. They function best when the instructional objectives are rigid and unchanging and the final performance is specified both in kind and quantity. i.e. the final evaluation is likely to be criterion referenced and of the all or nothing variety. A possible application of these models would be in the learning of basic number facts in mathematics or in the development of conversational fluency in a second language.

The Preferential Model is the third one outlined by Salomon (1971). The basic theory underlying this model is that an instructional treatment should be designed to exploit the student's current aptitudes. "It is 'preferential' in the sense that the treatment plays to the learner's preferred style or information processing strategy (Salomon, 1971, p. 11)." The treatment used under the preferential model should be one which enables the student to use his particular abilities to their fullest extent. It is this type of model which is used as the basic theoretical framework for this study.

Interactions, under this model, only result when some students are placed in environments that do not match their information processing strategies. Under such conditions, they do not perform to the extent that they are capable of. The aptitude of the student under this paradigm is a general one. It is more closely related to a style or combination of specific capabilities and strategies than to a task

specific skill like that found to work best under the compensatory model.

The search for ATI under this paradigm is described as follows:

> Practically, this model suggests that when treatment 'A' is found to correlate with an aptitude of type 'a', it is necessary to find what the low 'a' scorers are better able to do. Hence, it is a search for an aptitude which correlates negatively with aptitude 'a' and consequently also with learning from treatment 'A'. Only then is it possible to design an alternative to treatment 'A' which will call into use the aptitude that low 'a' scorers are more able at (Salomon, 1971, p. 13).

Learning Theories as Potential Sources of ATI

The Conceptual Level Matching Model which originated with the work of Harvey, Hunt, Schroder, and associates (Harvey, Hunt, and Schroder, 1961; Hunt and Joyce, 1967; Hunt, 1971) is an example of a model suited to the preferential framework. The model considers educational objectives, learner characteristics, educational approaches, and theories of instruction. It is hypothesized that the low Conceptual Level learners (categorical, dependent on external standards, and incapable of generating their own concepts) will profit from highly structured instructional techniques. High Conceptual Level students would benefit from more low structured approaches, or, possibly, be unaffected by the degree of structure.

It should be noted that the aptitude of high Conceptual Level is actually a combination of specific capabilities. It reflects a preferred information processing strategy possessed by certain types of students. It is not task specific, but

has application to a variety of learning situations. Also, the instructional environment does not have to be very specific. It can accommodate a variety of instructional techniques providing they are compatible with the requirement of being unstructured.

In a recent article Hunt (1970) extends his model to include additional possible person-environment combinations. This is accomplished by viewing the learner in terms of accessibility channels. Examples of accessibility channels are the cognitive orientation of the learner; the motivational orientation of the learner; the value orientation of the learner; and, the sensory orientation of the learner. These, in turn, affect the structure of the presentation, the form of feedback and reward, the value context of the presentation, and the modality of the presentation. This opens up the possibility of ATI's among such things as the preferred sensory system, the type of presentation, and the environmental situation; i.e. a three-way interaction.

Hunt's Conceptual Level Matching Model views the educative process entirely from the point of view of the learner's cognitive structure. The problem, when approached this way, is one of adapting the instructional environment and method of presentation to the individual. There appears to be a twofold purpose in this: (a) to provide an optimal learning environment for a particular instructional episode; and, (b) to raise the conceptual level of the student. Thus the student is provided with an environment that <u>nearly</u>

matches his Conceptual Level. He then has to adapt his approach somewhat to make the match more exact and is thus led towards a higher Conceptual Level. The process is, at the same time, preferential and also educative.

An alternative approach to the ATI question considers the problem in light of the different kinds of capabilities which must be learned. This is best exemplified by the work of R. M. Gagné (1962, 1964, 1967a, 1967b, 1970). He distinguishes eight different classes of learning each with its corresponding set of conditions. Interactions, when interpreted within this framework, must occur between the treatment (conditions of learning) and the desired result (kind of learning). The individual learner is regarded as possessing a set of capabilities which will allow him to learn anything, given that it is appropriately structured. The role of the learner is that of the medium who makes learning possible. This does not exclude the role of individual differences in the learning situation. According to Gagné (1970):

> there are as many varieties of learning as there are distinguishable conditions for learning. These varieties may be differentiated by means of descriptions of the factors that comprise the learning conditions in each case. In searching for and identifying these, one must look, first, at the capabilities internal to the learner, and second, at the stimulus situation outside the learner. Each type of learning starts from a different point of internal capability, and is likely also to demand a different external situation in order to take place effectively (p. 24).

Specifically excluded from Gagné's discussion are the many personal interactions between the learner and teacher. Such conditions, especially personality characteristics, are

acknowledged to be important, but are beyond the limits of the structure proposed.

Gagné views learning as a hierarchical process. All of the prerequisite capabilities he postulates are internal processes. They may be conceptualized as being analogous to cognitive structures. The external conditions are established by instructional and environmental conditions. Interactions may occur under this model only in the sense that each learning type has prerequisite internal structures and an optimal external set of conditions for its development. To fail to consider the current internal cognitive structure of a learner would mean the instructional techniques might be inapproapriate and the learning desired minimal.

Consideration of this model indicates that it is a rather poor base for discovering ATI. It would be expected that most learning differences between students measured on the basis of this structure would be reflected in various ability tests. As such, the simplest explanation for them is likely to be initial differences in cognitive ability. Personality and cognitive style variables are thus largely superfluous constructs under Gagné's system.

Bloom (1956) takes an approach similar to that of Gagné's. The student is regarded as a passive agent that is to be sequentially supplied with certain increasingly complex capabilities in the cognitive domain. Four decisions with respect to the student and curriculum are to be considered.

> How much knowledge should be required learning?; How precisely need the student learn the required

> knowledge?; How is knowledge best organized for learning?; and How meaningful need required knowledge-learning be to the student? (Bloom, 1956, p. 36).

Questions three and four are especially relevant to ATI interpretations. However, the answers are left to the discretion of the teacher. Bloom's taxonomy simply provides an additional hierarchical structure to consider in analyzing the curriculum in terms of kinds of cognitive capabilities required by the student. It provides both a set of objectives which are potentially significant and a set of quasi-intellectual processes required for attaining them. For example, level 5, Synthesis, is defined as

> the putting together of elements and parts so as to form a whole. This is a process of working with elements. parts, etc..., and combining them in such a way as to constitute a pattern or structure not clearly there before. Generally this would involve a recombination of parts of previous experience with new material, reconstructed into a new and more or less well-integrated whole (Bloom, 1956, p. 162).

Clearly the ability to synthesize calls for what Hunt (1971) would call a high Conceptual Complexity. In fact, "the principle of complexity was developed as the major ordering basis for the cognitive domain (Krathwohl, Bloom, and Masia, 1964, p. 10)." Also, it is apparent that the attainment of the capability is going to be a gradual process which is likely to be facilitated by various matches between learner characteristics and instructional techniques.

The Affective Domain is ordered along a continum of increasing "internalization". The five categories are: 1.0 Receiving (attending); 2.0 Responding; 3.0 Valuing;

4.0 Organization; and 5.0 Characterization by a value or value complex. (Krathwohl, Bloom, and Masia, 1964). Again, the emphasis is on an increasingly complex inner structure.

Both Gagné's and Bloom's presentations are oriented towards curriculum objectives. As such they tend to downgrade the importance of the individual student. To a large extent they assume an optimum possible match between the instructional objective and the instructional technique. Once this is satisfactorily achieved, all students should be able to master the objective. This does not always occur, however. Under a fixed instructional treatment, there are many students who do poorly. Others fail. i.e. they are unable to master the instructional objectives under the treatment provided. Apparently a major reason for the failures is that the instructional procedures are inappropriately matched with individual student aptitudes.

Bloom, in his most recent work (Bloom, Hastings, and Madaus, 1971) has proposed a way of avoiding failures. Building on a model originally proposed by Carroll (1963), he is currently advocating the concept of mastery learning. According to Bloom:

> Most students (perhaps more than 90 percent) can master what we have to teach them, and it is the task of instruction to find the means which will enable them to master the subject under consideration... Basically, the problem of developing a strategy for mastery learning is one of determining how individual differences in learning can be related to the learning and teaching processes (Bloom et al., 1971, p. 43, 44).

This approach still seems to negate the importance of non-cognitive abilities as potential sources of differential performance. However, a major problem is that current educational environments provide a very limited range of options for adapting to individual differences. In most settings, the general cognitive ability type aptitudes are more important than any specific affective or study behavioral kinds of aptitudes. Thus, under most instructional treatments, the initial distribution of cognitive abilities determines the final distribution of success at the end of a given time period. The mastery learning paradigm attempts to overcome this by subjecting individual students to the same basic treatment, but for different amounts of time.

According to this model,

> if the students are normally distributed with respect to aptitude but the kind and quality of instruction and the amount of time available for learning are made appropriate to the characteristics and needs of *each* student, the majority of students may be expected to achieve mastery of the subject (Bloom et al., 1971, p. 45).

The maximizing of the match between learner characteristics and needs and the kind and quality of instruction becomes the classical search for ATI. The only different feature is that, under a mastery learning paradigm, time becomes a means of varying the treatment.

Lesser (1971) brings together a collection of articles which illustrate different ways in which instructional techniques can be adapted to particular types of students. Given the existence of individual differences, a major

question is "How should an accurate diagnosis and interpretation of individual differences affect the form and timing of instruction and the choice of education goals (p. 7)?" He goes on to suggest that "even given a single universal goal for all students, different instructional strategies must nevertheless be matched with the different student capabbilities (p. 531)." Thus ATI in this case will occur between a genuine learner aptitude and an educational treatment. Lesser further enlarges the field to include the individualization of educational objectives. It is the setting of the educational goals which is one of the major problems. Such goals are of two types. Universal goals define objectives to be mastered by all students. In addition there are certain individual goals which must be tailored to each child's individual characteristics. Each of these will require the development of different instructional strategies.

According to Lesser (1971), most adaptations made to accommodate individual differences in the instructional setting are organizational in nature. One of the primary drawbacks of most grouping and differentiation procedures is that they tend to create "classes" of students. The top groupings become academic elites while the lower classifications become dumping zones for potential school drop-outs. A further limitation is that the structure of the program is usually quite inflexible under a particular grouping. Such measures are unlikely to provide a significant source for ATI. Instead, they perform a screening function

by keeping out students who are thought to be unfit to function at more advanced cognitive levels. Thus they tend to ignore the original problem. i.e. what can be done for those students who do not function under the traditional school organization and instructional techniques?

Lesser (1971) lists a number of possible pedagogical adaptations to individual differences. These include varying the structure of instruction; varying the difficulty level of the instructional material; varying the setting of instruction; and, varying the type of reinforcement accompanying instruction. Any one of these techniques require a knowledge of the individual student's particular characteristics. All of them are potential sources of ATI's.

Learner styles are also noted as potential sources of interactions. For example, a three-way interaction is possible between the subject matter, the instructional method, and the student's learning style. A cognitive style is defined by Kogan (1971) as "individual variation in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information (p. 244)." He describes nine distinct cognitive styles as elaborated by Messick (1970). After reviewing the various studies on which these cognitive styles are based, Kogan states that "it is in the area of the interaction between variables of instruction and cognitive styles that the research evidence is most limited (p. 291)." This indicates a need for more studies on ATI and indicates

at least nine areas where they could begin.

Kogan (1971) mentions one additional point. He questions the desirability of structuring instructional techniques to a student's style in all cases. Instead it may be desirable under certain circumstances to attempt to change the student's style. As Kogan states it "An obviously desirable goal is to provide the child with the ability to shift his cognitive approach in the face of changing task requirements (1971, p. 291)." This indicates a need for additional research to determine the extent to which cognitive styles can be altered. Thus in addition to specific ATI's, one must consider the extent to which the interaction between treatment and aptitude alters the final aptitude itself.

Some Studies Illustrating ATI

Some empirical evidence for Hunt's Conceptual Level model is found in studies by Tomlinson (1969) and McLachlan (1969). Both studies investigated the interactive effects of learner Conceptual Level and variations in structure represented by discovery and lecture approaches to instruction. The discovery technique was taken to represent the low structured approach while the lecture method was taken as representative of a high degree of structure. The results of the McLachlan (1969) study indicated an ordinal interaction illustrating the compensatory model. It was found that the low Conceptual Level students

performed significantly better ($p < .05$) with the lecture method than with discovery. No differences were noted for the high Conceptual Level students indicating that they functioned equally well in either environment.

The Tomlinson study used three levels of structure. These ranged from discovery (examples only) to guided discovery (examples, then rules) to a lecture format (rules, then examples). It was found that under conditions of low and intermediate structure, the low Conceptual Level groups were significantly lower ($p < .05$) than the high Conceptual Level groups under the same conditions. Further, the low Conceptual Level groups under low and intermediate structure were also significantly lower ($p < .05$) than the low Conceptual Level group under high structure. A graphical representation of the results indicated a disordinal conceptual level by treatment effect. However, the interaction, when tested, was found to be nonsignificant.

A study by Chalmers (1972) found an overall interaction among teacher and student information processing styles which significantly affected student decision-making performance. It was found that "optimal student performance results when students and teachers are matched on one style of information processing and not matched on another style (Chalmers, 1972, p. 100)."

The study categorized teachers and students on the basis of reflection-impulsivity. Two specific interaction effects were found using student decision-making performance

as the criterion. Reflective students taught by a high differentiating teacher had low decision making performance scores. The second interaction involved a combination of student and teacher information processing styles. Student decision-making performance was found to be best when both students and teachers were high on differentiation, but neither students nor teachers are both all reflective or impulsive. An analogous result was found when students and teachers were matched on reflection-impulsivity. Best student performance was found in the case where the differentiation styles of the teacher and student differed.

The results of this study indicate that optimal student performance results when students and teachers are matched on one information processing style and mismatched on another. The implications are that growth can be best induced by providing instructional environments which capitalize on a particular strategy, but require further development of another one. Under this paradigm, a student's information processing style becomes a many faceted entity. Also, it tends to combine both the compensatory and preferential models under one framework.

The results of the above study support Hunt's model for optimal match-mismatch of instructional environment to student characteristics. They also address the questions raised by Kogan (1971).

Further evidence for the existence of complex learner styles is found in studies by Oliver and Shaver (1966, 1968). They demonstrated that students low in authoritarianism, low in the tendency to dichotomize, low in the need for structure,

and high in the ability to tolerate hostile action performed best under a "Socratic" method of instruction. Students with an opposite set of characteristics were found to perform better under "Recitation" methods.

Learner styles are also found in a study by Biggs (1970a) He found that student study behaviour interacted with performance in first year Arts and Science courses. Simpl ing and self-structuring styles were found to be related to success in Arts, but not in Science.

A relatively early study by Grimes and Allinsmith (1961) found ordinal interactions using the personality variables of compulsivity and anxiety. It was found that under structured teaching compulsive children do substantially better than less compulsive children, but compulsivity makes no difference in the unstructured setting. Anxiety, in contrast, made no difference under structured conditions, but inhibited performance in the unstructured setting. They also found that "children who are both highly anxious <u>and</u> highly compulsive overachieve strikingly in the structured environment, and those who are highly anxious but <u>low</u> in compulsivity underachieve in the unstructured schools (Grimes and Allinsmith, 1961, p. 272)." This study supports the compensatory interaction model.

From the few studies examined in detail, it appears that, when there is a unidimensional aptitude involved, interactions tend to be ordinal and the paradigm for ATI is that of the compensatory model. On the other hand, when a

combination of different aptitudes or an information processing style is involved, the interactions tend to be disordinal and the ATI model is the preferential one. There is also evidence that the preferential type of ATI results in superior performance for those individuals that are optimally utilizing their preferred style while learning parts of another strategy. The situation under the compensatory model is not quite as ideal. It appears that the maximum increment in performance possible merely enables the learner to function at a level equivalent to others who already possess the aptitude in question or an equally effective alternative one. From an educational point of view, both of these processes are important, but the latter one seems to offer the most potential for the development of the student, especially if it is acknowledged that both learning and an increasing capability to learn are valid objectives of the educational process.

Some Unsuccessful ATI Research

The first major compilation of ATI investigations and experiments purporting to demonstrate ATI was that of Cronbach and Snow (1969). The chief result of this study was to show that most of the interactions found in the psychological literature were not significant. A further finding was that in many investigations where ATI's were potentially present, the analysis of the results was inappropriate for detecting them.

Two major problems which Cronbach and Snow (1969) indicate must be solved are the conceptualization of aptitude

dimensions and treatment dimensions respectively. They suggest trying to find two different treatments, one of which would be correlated with general ability, the other related to a specific aptitude. Under this paradigm, the interaction effect would be between treatments and persons high in general ability or high in a particular aptitude, but not those persons high in both.

Bracht (1970) did a further extensive review of the literature in which ATI's were reported. Ninety studies were found which were designed to permit a test of ATI. For each study the treatment tasks, personological variable, dependent variable, and interaction effect were classified into one of two categories. The treatment effect was classified as disordinal "if the treatment differences at two levels of the personological variable were both significantly non-zero and different in algebraic sign ... (Bracht, 1970, p. 632)." This condition was accepted as evidence for ATI.

Out of one hundred and eight studies reviewed, Bracht (1970) found only five which met his criteria for a disordinal interaction. One hundred and three showed only ordinal interactions or no evidence for any kind of interaction. In concluding, Bracht, in agreement with Cronbach and Snow (1969), states that "it seems that the two major factors in the occurrence of ATI are the nature of the alternative treatments and the selection of the personological variables (1970, p. 639)." A minimum of two personological variables should be included in any experiment for studying ATI. Ideally

these two variables should not be correlated with each other and each should correlate substantially with a different treatment.

A major attempt to apply the Cronbach and Snow paradigm for discovering ATI's is found in a study by Goldberg (1971). College students were taught by two different methods. One method involved a highly structured, teacher-oriented type of presentation; the second a loose, independent, student-oriented type. "The program (was) predicated upon an assumption that no single college instructional procedure will be best for all students, but rather that there is an interaction between the personality of the student and the optimal method of teaching him (Goldberg, 1971, p. 1)."

Three hundred and fifty personality test scores were obtained for each of the approximately nine-hundred subjects tested. The personality measures were representative of the most commonly used commercial tests available. Each personality measure was tested for interactions with both the criterion performance measures and the type of instruction. The ratio of observed interactions to those that would be expected by chance under the analysis technique used was approximately four:three. As a result, it was concluded that no "real" interactions were found and "it still seems safe to assert that new predictions made on the basis of the most significant interaction effects are unlikely to be more valid than those made on the basis of general predictions alone (Goldberg, 1971, p. 121)."

Implications of Reviewed Research for This Study

One conclusion which seems reasonable on the basis of the Goldberg (1971) study is that the traditional descriptive type of personality test is not particularly suited to defining aptitudes relevant to determining ATI. Most such tests have been developed with particular diagnostic or placement objectives in mind. They were not designed with any consideration for the possibility of different treatments. Further, the procedures used in their validations tend to ignore any variations in the environments where the tests are administered. Also, they tend to measure rather specific aptitudes which are unlikely to be of the generalized type that can lead to differential performance as a function of environment or information processing strategies.

The types of aptitudes selected for measurement in this study are designed to give a sampling of the students' affective and behavioural characteristics as they pertain to the domain of academic learning. The nine SBQH subscales (R-subscales) are each designed to measure a particular unidimensional aptitude. The subscales defined by the Q-technique are a measure of aptitudes and behaviours that specifically combine to form a complex that is itself defined by performance under the treatments themselves. Thus this study is a search for aptitudes which are most likely to be relevant to academic performance. It is also concerned with determining whether ATI is more likely when the aptitude is unidimensional or multidimensional.

Specific Objectives of this Study

A major intent of this study is to address some of the problems in previous research that appear to account for the fact that such ATI studies have been surprisingly unproductive. There are two issues which are specifically addressed. The first is to attempt to sample either affective or behavioural aptitudes which are important to the academic performance of the student but which are, at the same time, independent of cognitive ability. The second problem to overcome is that of an inadequate matching of the aptitude with the treatment. To this end, an attempt will be made to find out whether the aptitudes which interact are unidimensional, enduring characteristics of the student or if, instead, they are a series of multidimensional ad hoc collections of simple aptitudes which are assembled to attack a specific task.

This study, then, attempts to answer the following questions:

(1) Can aptitudes that lead to differential student performance through interaction with the different instructional treatments be identified?

(2) Are such aptitudes unidimensional (R-aptitudes) or multidimensional (Q-aptitudes)?

Hypotheses Examined

The basic hypothesis examined in this study is that individual students have particular affective aptitudes or study behaviour strategies which lead to differential levels of cognitive attainment under differing instructional

treatments. There are two major assumptions which underlie the testing of this hypothesis. The first is that the SBQH is capable of measuring some of the students' more important study behaviour aptitudes. The second assumption is that the two treatments do indeed provide different instructional environments. Evidence supporting these assumptions is presented in Chapter three.

A second purpose of this study is to see if Q-technique can provide a method of classifying subjects that will make the detection of aptitude-treatment interactions easier. The assumption is that the Q-method will provide a convenient means of grouping individuals on the basis of common characteristics, on the grounds that an individual's study behaviour style may be made up of a group of different aptitudes rather than a single unidimensional one. Further, there may be certain combinations of aptitudes which are common to particular groups of individuals.

Chapter 3

Research Instruments, Teaching Strategies, and Procedures

Introduction

Two research instruments were developed for this study. The STUDY BEHAVIOUR QUESTIONNAIRE, High School Version and a Biology 20 Cognitive test were constructed. In addition scores from the quantitative scale of the School and College Ability Test, SCAT, were used as a measure of each student's cognitive aptitude for biology.

Development of the STUDY BEHAVIOUR QUESTIONNAIRE (SBQH)

The questionnaire used to sample the student's aptitudes in this study is a further development of a STUDY BEHAVIOUR QUESTIONNAIRE first used by Biggs (1970a). Study behaviour, as defined in the context of this questionnaire, is regarded to be a combination of complexly determined modes of information processing. "Study behaviour is regarded as the translation, in the context of study, of certain enduring personality characteristics, into a series of operations or strategies (Biggs, 1970a, p. 163)."

THE STUDY BEHAVIOUR QUESTIONNAIRE, High School Version, SBQH, contains nine unidimensional subscales. Each of these was selected on the basis of its relevance to the problem as determined by empirical findings in previous studies. The original SBQ, on factor analysis, yielded six factors which were interpretable. These were named:

(1) Study Organization; (2) Tolerance of Ambiguity; (3) Cognitive Simplicity; (4) Capacity for Intrinsic Motivation; (5) Dogmatism; and (6) Independence of Study Behaviour, respectively (Biggs, 1970a).

The constructs which the scale was intended to measure included intolerance of ambiguity (Frenkel-Brunswick, 1949), dogmatism (Rokeach, 1960), cognitive complexity (Bieri, 1966; Schroder, Driver and Streufert, 1967), and convergence-divergence (Hudson, 1966, 1968). All of these dimensions are included (under different labels) in a listing of nine cognitive styles which have been found to be empirically reproducible (Messick, 1970). Evidence supporting the construct validity of the original SBQ is presented in a follow-up paper by Biggs (1970b).

A refined version of the original SBQ was used in a second study (Biggs, 1971). The latter version consisted of items adapted from the previous questionnaire together with additional items referring to the student's attitudes towards university and his coursework. Following the procedure outlined in a study by Braun (1970), seven empirical scales were obtained by the method of homogeneous keying. The method is designed to produce item clusters with maximum scale consistency and was developed by Dubois, Loevinger and Gleser (1952). In addition, four a priori scales, based on the original SBQ were added to give eleven subscales in total.

The major change introduced by the above procedures was to separate the SBQ subscales into two distinct

categories. These were labelled "Value-Motivational" and "Study Strategies" respectively. Five subscales labelled respectively Pragmatism, Class Orientation, Academic interest, Achievement Interest, Achievement Organization, and Academic Neuroticism made up the Value-Motivational domain. Of these the first four were empirically derived while the last was specified on an a priori basis.

The Study Strategies domain was defined by six subscales. The first three, Wide reading, Simplifying, and Fact-Rote were empirically determined. Scheduling, Dependence, and Relating were based on the original SBQ and included on an a priori basis.

A further revision of the SBQ was performed in 1972. The new questionnaire, the SBQJ, was based on empirical results obtained from the Biggs (1971) study. The theoretical framework for both the new and the earlier versions was an interactive learning model based on an information processing theory of learning (Biggs, 1969). Under this theory, personality factors are postulated as interacting with cognitive variables in determining the quality of learning. The learning model on which this theory is based can be outlined as follows:

(PERSONALITY) × (ACADEMIC VALUE-MOTIVATION) × (BEHAVIOURAL STRATEGY) = PERFORMANCE

Academic performance is visualized as being mediated by a number of factors. The net result may be likened to a style or preferred method of information processing. It suggests that there is an optimal combination of aptitudes

which, when activated in an interactive manner, will produce a best performance. Further, this style may be dependent on the nature of the task in question.

On the basis of this model and previous research the new SBQ includes subscales representing the personality, academic value-motivational, and behavioural strategy spheres.

Ten items from each SBQJ subscale were selected and modified to fit the high school situation. In some cases this merely involved changing the word lecturer to teacher; in others, the item was extensively revised. This initial version of the test, consisting of ninety items, was pilot tested on a sample of Grade 10 and 11 chemistry and biology students at a city high school not used in subsequent parts of this study. Approximately one hundred and fifty students were tested. The results of this test were analyzed by the multiple-groups factor analysis technique (Harman, 1967).

The items included in each subscale of the SBQH were selected on an a priori basis as representative of the domain in question. According to Harman (1967), "Guttman and Holzinger suggest that the multiple-groups methods be used in conjunction with some <u>a priori</u> psychological theory (p. 234)." For these reasons a variation of the multiple groups factor analysis technique was performed on the results of the pilot test.

The first step in the technique was to calculate the matrix of intercorrelations among the items for each subscale. Following this the first principal component was extracted.

Component scores were then determined for each person on the first principal component for each subscale. The oblique factor structure matrix, S, was then determined by premultiplying the matrix of factor scores by the inverse of the original data matrix. Following this, the matrix of correlations between the oblique components, ϕ, was calculated. Finally the oblique factor pattern, P, was derived according to the following equation; $P = S\phi^{-1}$.

The entries in the P matrix were used to make the selection of items for the final version of the SBQH. Single values of P_{jq} above 0.300 were arbitrarily taken as confirming that a particular variable was to be included in the subscale. Variables which could be predicted from two or more components and variables predicted from components with P_{jq} of less than 0.300 were dropped from the questionnaire as being unrepresentative of a particular subscale.

As a result of the analysis, sixty-five of the original ninety items were retained. An additional ten items were then added on an arbitrary basis. These were minor revisions of items from the original questionnaire which had failed to meet the criteria for selection outlined above. The final questionnaire thus consisted of seventy-five items spread over nine separate subscales. Seven of the subscales contained eight items each, one contained nine, and another had ten items.

The subscales in the final version of the SBQH

(Appendix C) were designated as follows: (1) Fact-Rote; (2) Study Skills and Organization; (3) Instrumental Motivation; (4) Meaning Assimilation; (5) Academic Neuroticism; (6) Academic Motivation; (7) Test Anxiety; (8) Internal-External; and, (9) Dependence. These were selected to give a sampling of portions of each student's study behaviour characteristics.

The Fact-Rote and Meaning Assimilation subscales were included to determine the students' basic strategy for assimilating knowledge. It was assumed that the students that preferred learning by a meaningful method would perform better in an unstructured, independent type of environment while those who rote learn should do relatively better in a structured situation. It was further assumed that high scores on the Study Skills and Organization and Academic Motivation subscales would indicate an "academic" type of student interested in learning and likely to perform better than students lacking these characteristics in any situation which required independent action. Students scoring high in Instrumental Motivation should be those, who, while not necessarily interested in the subject matter, are motivated to do well for the competitive advantage this gives them. This type of student should perform well regardless of the instructional environment. The Test Anxiety subscale should give an indication of the students' attitude towards evaluation. This is probably independent of the instructional setting and more affected by the nature of the evaluation

procedures used.

Students with high scores on Academic Neuroticism, Dependence, and Externality (i.e. low internality scores) should perform better in a traditional structured type of setting. It is assumed that this kind of student does not function well on his own. Instead, he wants lots of supervision and direction in order to do his best work. High scores in the opposite direction should be indicative of a type of student who can perform well in an independent setting where direct teacher supervision is minimal. Possibly the performance of this latter type of student will even be inhibited under highly structured conditions.

On the basis of the above assumptions, the subscales which should be most likely to lead to disordinal types of interactions are the Fact-Rote, Meaning Assimilation, Academic Neuroticism, Dependence, and Internal-External ones. The Academic Motivation and Study Skills and Organization subscales are potential sources of ordinal type interactions. No interactions involving the Test Anxiety and Instrumental Motivation subscales would be expected.

All items were scored on a five-point Likert-type scale with a score of 5 indicating high agreement. No items were reversed. However, it was felt that the nature of the questions was such that subjects would not develop a definite response bias. The items were listed in order by subscale. Thus every ninth item was from the same subscale. This procedure was used to facilitate scoring. Strict random

assignment of the variables was deemed unnecessary because of the relatively large number of subscales used.

The SBQH was administered to the sample of students in the control and experimental schools once at the beginning of the semester and again two weeks from the end. This gave a period of about five months between the two administrations. The results of the second testing were used to determine the test-retest reliability (stability) of the SBQH.

Subscale scores from the first administration were selected as the measure of each student's aptitudes for the purposes of this study. Each subscale was scored separately and, since the number of items in each was not equal, the subscale scores for each individual were converted to z-scores. The standardized subscale scores were used in all subsequent analyses.

Validity of the SBQH

On the basis of studies using the original SBQ (Biggs, 1970a; Biggs, 1970b) the SBQH appears to be measuring aptitudes related to the student's study behaviour. It thus has a degree of face and construct validity. Also, the multiple-group factor analysis procedure assures that the items in each subscale are measuring facets of the same aptitude. In addition, the SBQH appears to be measuring aptitudes that are educationally important.

Reliability

Results of the test-retest reliabilities for each

subscale of the SBQH are given in Table I. These indicate a fair degree of stability over the five month time period. The alpha-coefficients for each subscale are also given in Table I. They indicate that the variables selected to represent each subscale aptitude are relatively homogeneous.

The Biology 20 Cognitive Test

A test (Appendix D) designed to measure the cognitive objectives of a common portion of the Biology 20 curriculum was constructed by biology teachers from the experimental school. This test was administered to the students of each group at the end of the semester. Because of lack of time, there was no pilot testing to screen out poor items. Therefore, the test results from each group were subjected to separate item analysis to detect poor items. Five items were found to be unacceptable in either group. Three additional items from each group were found to be poor within that particular group. For reasons of validity it was decided that only the five items which were below the arbitrary criteria of selection in both groups would be omitted. The criteria used for the selection of acceptable items were a point-biserial correlation coefficient of 0.30 and an item reliability index of 0.15. Items which did not meet both of these limits were excluded from the test for scoring purposes.

In order to derive the students' criterion scores, the control and experimental groups were combined and scored on the thirty-seven items of the final test. The score used in

TABLE I

Reliability Data for the SBQH

Subscale	Test-Retest Reliability (Stability) (n = 565)	Alpha Coefficient of Reliability (Internal Consistency) (n = 156)
Fact-Rote	.34	.61
Study-Skills and Organization	.41	.76
Instrumental Motivation	.38	.70
Meaning Assimilation	.32	.67
Academic Neuroticism	.39	.64
Academic Motivation	.34	.69
Test Anxiety	.44	.74
Internal-External	.31	.55
Teacher Dependence	.35	.47
Average	.36	.65

*Values reported are the average of all the test-retest correlations for each variable in the subscale.

subsequent analyses was the total of the correct responses for each individual.

Validity

Some of the questions used on the biology test were prepared by teachers at the experimental school and the remainder were obtained from the BSCS Resource Book of Test Items for the Yellow Version of the BSCS series. All questions included in the final test were approved by biology teachers from the control school.

The content areas examined by the test dealt with evolution and plant and animal morphology. Evolution is taught in Biology 10 at the control school, while at the experimental, it is treated as a major introductory unit in Biology 20 and is then used as a central unifying theme throughout the study of plant and animal morphology. Plant and animal morphology is the central topic in Biology 20 at the control school.

Because of the way the questions were constructed and, also, due to the different instructional emphasis, the final test was probably biased in favor of the students at the experimental school. The main consequence of this is that, if the means for the graphs are quite different, a potential disordinal interaction may appear as ordinal.

The items on the test, when classified according to the Taxonomy of Educational Objectives (Bloom, 1956), were found to be about 75% from the Knowledge and Comprehension categories. Both of these categories were approximately

equally represented. The remaining 25% of the test items were nearly evenly divided between the Application and Analysis categories. The higher processes of Synthesis and Evaluation were not tested.

The emphasis placed on the different levels by the test seems to be in accordance with the instructional objectives of the experimental school. Analysis of a UNIPAC (by teachers at the experimental school) revealed that 67% of the objectives specified were at the Knowledge level. The remaining 33% were distributed throughout the higher levels.

The fact that the test mainly measures lower level cognitive processes is a limitation when it is considered as an instrument for detecting ATI. It is possible that the learning of such basic factual material is more dependent on the amount of exposure the student has to it then it is on the method of presentation. Thus, students might learn equally well under either treatment. On the other hand, the test covers a content area which represents an integration of an entire semester's work. On this basis, it can be argued that the final performance of the student should be a reflection of both his cognitive ability and the degree to which his particular study behaviour aptitudes have matched the instructional environment. If this is the case, and, given evidence that the instructional environments are different, then the test should still provide a reasonable criterion score for detecting ATI.

Reliability

The test results on the thirty-seven items for the combined groups were subjected to an item analysis. The Kuder-Richardson Formula 20, KR-20, reliability for the final version of the test was found to be 0.74. The test mean was 21.6 and the standard deviation 5.8.

The SCAT Scores

Stanine scores from the quantitive subscale of the SCAT were used for classifying students in terms of academic aptitude. Within a particular quantitative score value, the students were further ranked from high to low on the basis of their verbal scale score. Thus a student with a quantitative score of seven and a verbal score of eight would be classified for the purposes of this study, as higher on academic aptitude than one whose scores were seven and six respectively. The quantitative subscale was chosen as the basic measure since it correlates more highly with performance in the science and math areas than the verbal score (SCAT-Step Supplement, 1962). Also, the weighted total score was not available.

Validity and Reliability of SCAT Scores

Validity and reliability data for the SCAT are reported in detail in the test manual. These data support the contention that the test provides a reliable and valid estimate of a student's academic aptitude.

The Sample

Approximately one hundred and fifty students registered in classes of Grade 10 and 11 Biology and Chemistry were used in the pilot administration of the SBQH for determining reliability. Students who participated in the main study were those registered in the same courses as above during the second semester at the control and experimental schools. Because of various procedural difficulties, the total sample was not used in all stages of the investigation. For example, out of approximately nine-hundred students first tested on the SBQH, only five-hundred and sixty-five could be matched against the post test data five months later. In general, at each stage of the procedure, the maximum number of subjects for whom complete data was available was used. This number will be reported with the results of each stage of the analysis.

The final cognitive test was administered only to Grade 11 Biology students in the two schools. This sample was further restricted when papers without names and subjects with missing SCAT data were dropped from the study. This gave a total of seventy-eight subjects with complete data at the experimental school and seventy at the control school.

The Teaching Strategies

Two different methods of instructing high school biology were selected as the treatments for this study.

This instruction was conducted in two schools which were arbitrarily designated Control and Experimental. Both schools covered the same basic Biology 20 curriculum, but with a different instructional emphasis.

The object of the course, as presented by the teachers at the experimental school (Appendix A), was "to enable the teacher through an individualized approach to evaluate more effectively the needs of each individual student (Appendix A, p. 2)." Furthermore, the student was expected to undergo a learning experience which would allow for maximum development in both his cognitive and affective domains.

A more detailed statement of their aims follows:

> The major objective of Biology 20 is to allow the student the opportunity to study the diversity of living things by examining closely the representatives from different groups of organisms. Unipacs will be issued and they will serve as a guide to student learning. Unit objectives provide the student specific goals to attain and the path by which these end products may be attained is through the learning activities (Eliuk, Makowecki, and Ballash, 1972, Appendix V).

The description of the experimental program which follows is taken from the report submitted to the Edmonton Public School Board by Eliuk, Makowecki, and Ballash (1972). They state that the objectives of the program were developed to allow a student to progress through a series of units of his own choosing according to his own ability and speed. Each unit was alloted a suggested time for completion, but this was not enforced upon the students. Each student picked a unit, completed the various activities (textbook readings, taped lectures, filmstrips, transparencies, and

exercises) and asked for an examination when he felt that he had mastered the detailed learning and behavioural objectives. In the Biology 10 portion of the course, if a student failed an exam, he was allowed to do more work on the unit and rewrite a parallel form of the original test. In Biology 20 no rewrites were granted. Instead, an oral examination was given which required each student to demonstrate a mastery of material in four units that fell into a sequence. This required an integration of the units and was designed to allow the students to acquire an understanding of the interrelatedness of the various topics.

At the end of a semester, students who had not accumulated a minimum number of units were given a progress mark and allowed to continue at that point at the beginning of the next semester. A two semester time limit was imposed for completion of the Biology 20 course. A complete outline of the Biology 20 course, as it is presently organized, is given in Appendix E.

"The role of the teacher in the program was that of a learning helper and motivator (Eliuk, Makowecki, and Ballash, 1972, p. 6)." The majority of classroom teacher time was spent talking and working with individuals and small groups. Table 2 is a summary of the amount of teacher time spent in the various types of activities required under the UNIPAC approach.

In the control school, instructional procedures were conducted under a more traditional format. The Biology 20

TABLE 2

Distribution of Teacher Time Under the Unipac Approach

Activity	Percentage of Time Used
Class Lectures	20
Small Group Lectures	15
Working with Individual Students	45
Evaluating Individual Students	20

curriculum was structured according to the Department of Education Curriculum Guide. More time (approximately 67%) was spent in classroom activities. All of the students covered the same basic material. Testing was done on a group basis.

Laboratory and project work occupied about 33% of the instructional time. Some experiments were structured as discovery learning situations. Others were used to supplement class presentations by providing illustrative examples of the material discussed.

The progress of individual students was more carefully regulated in the control setting. The instructional material was presented in a more uniform manner than in the experimental setting. Each student covered all topics on the course. Evaluation of the students was more systematic. All students in a class were given a common exam at a common time and their relative performances were determined on the basis of such evaluations. The material taught was largely structured by the teacher and presented in a uniform manner to all students in a particular class. The main student learning process would probably be most appropriately classified as one of meaningful reception (Ausubel and Robinson, 1969).

It would appear that the major difference between the two treatments was the amount of time the student had available for his own activities. At the control school, this seems to have been a maximum of about 33%. In the experimental school it appears that as much as 80% of the time could be student directed. A point that should be noted, however, is the fact

that up to 80% of the time in the experimental school could also be spent under teacher supervision. This included time spent in class lectures, small group presentations, and individual one to one interaction with a teacher. It should also be noted that most of this time could still be student directed since the teacher was expected to function as a resource person rather than as a director of activities.

It would also appear that a student could obtain more individualized attention under the experimental setting than in the control situation. The experimental treatment allows 45% of its student contact time for such activities.

Evaluation and grading procedures are another source of difference between the two groups. Evaluation in the experimental setting was on an individual basis using both written and oral examinations. It tended to be criterion referenced. At the control school the exams were common group ones and evaluation was more norm referenced.

The time spent by a student on a given instructional sequence appears to be another source of variation among the two treatments. In the experimental setting a student is allowed to progress at more or less his own rate. He can take two full sumesters to complete the course without repeating any of the material, or, he can complete both Biology 10 and Biology 20 in one semester. In the control environment all students progress at the same rate. A student who is not finished (does not pass) at the end of the semester must repeat the entire course. It thus appears that a student in

the experimental treatment can progress at much his own pace while in the control setting the student must work at a more uniform group rate.

On the basis of the differences discussed above, it appears that the two schools do provide different instructional treatments. The experimental environment would seem to be suited to the independent, inner directed, organized, motivated type of student. Also, it appears to be a good environment for the dependent, neurotic, outer directed student since he can use more of his time for direct teacher contact. The control setting, on the other hand, is designed more for the student who is comfortable in the traditional academic setting. He is neither especially independent nor dependent. Instead he functions best under a situation where he is given considerable direction tempered with moderate amounts of individual freedom.

Procedures

The SBQH was administered to the students at the beginning of the school term and again at the end. In addition, SCAT scores were obtained for those students that wrote the Biology 20 cognitive test.

Instruction in both the control and experimental schools was entirely under the direction of the class teacher. No attempt was made to evaluate individual teaching styles. It was hypothesized that differences in the type of instructional environment at the two schools would have to be greater than differences in individual teaching styles in order for

significant results to be obtained.

The criterion measure used to assess the success of the treatments was the set of scores obtained by the students in both schools on the Biology 20 cognitive test.

Limitations

There are a number of apparent limitations in the design of the study and the instruments used. The constructs of affective and behavioural aptitudes with respect to learning styles are only beginning to be elaborated. Consequently, studies using these are exploratory in nature. Further, the SBQH, which was used to measure these constructs, is also in the developmental stage. It requires further refinement, together with confirmation by other measures, before it can be considered to adequately measure the study behaviour characteristics of an individual student.

A major limitation in the design of the study was that the instructional processes were beyond the control of the experimenter in both the control and experimental schools. An additional problem was that only about one-quarter of the original sample was given a cognitive test. A further limitation was the fact that the cognitive test could not be pilot tested prior to its administration.

Because of the limitations discussed above, the results of this study can only be regarded as indicative of areas for further research.

Statistical Analysis

The statistical analyses of this study were conducted in two sections. First, the hypotheses relating to the SBQH or R-subscales were examined using a series of 2 x 3 x 3 factorial analyses of variance. For each analysis the students were classified on the basis of school, three levels of SCAT ability, and three levels of a particular unidimensional SBQH aptitude. Following the analysis of variance, a posteriori tests of cell means were conducted for all cases when significant F ratios were obtained to determine the specific source of the difference.

In the second section of the analysis, Q technique was used in an attempt to determine whether any multitrait subscales could be detected from among the original universe of variables making up the SBQH. The objective of the technique was to group a set of subjects on the basis of their responses to the individual items in the SBQH. The multidimensional Q-subscales defined by the technique were then subjected to the analysis of variance procedures using the same factorial design as employed with the unidimensional R-subscales.

Summary

This study was designed to investigate the possibility of interactions between students' study behaviour aptitudes and different instructional treatments. The presence of such interactions was assumed to affect the academic performance of particular students possessing or lacking a

particular study behaviour aptitude or information processing style.

In order to investigate this problem, the SBQH was developed to assess the study behaviour characteristics of the students. A content oriented test was used as a measure of the academic attainment of each student. The treatment consisted of the regular teaching procedures carried out at each school over an entire semester.

Chapter four presents the results of the study based on the analysis of data gathered from administration of the instruments described in this chapter, to the students who participated in this study.

Chapter 4

Data Analysis and Discussion

Introduction

A three way fixed effects model analysis of variance design was used to test the basic interaction paradigm proposed for this study. The program was developed at Human Engineering Laboratories (Butler, Kamlet and Monty, 1969). It was programmed and documented by the Division of Educational Research Services (DERS), University of Alberta. Data for the analyses were provided by the student's SCAT scores, SBQH and Q-aptitude scores, and the Biology 20 cognitive test.

Additional programs from the DERS library were used in the development of the SBQH; for scoring the data; for item analysis; and for the Q-technique.

Q-Analysis: The Derivation of the Q-subscales

Q-analysis was used to test the possibility that multidimensional study behaviors might show more of a relationship with performance on the cognitive biology test than the unidimensional SBQH aptitudes. The objective of the technique was to group the SBQH items on the basis of common characteristics of subjects. In this study the members of the experimental and control samples, their sex, and their Biology 20 scores were used for grouping the individual variables in the SBQH.

The procedure used in this study is a modification of that outlined by Braun (1972). The major steps in the analysis were as follows:

1. 48 subjects were selected from each of the experimental and control groups on the basis of their Biology marks and sex. Eight subjects were selected from among the sample at each of three arbitrary performance levels. The high performance groups consisted of scores of 25 and above, the medium of scores from 20 to 25 and the low of scores below 20. The eight subjects within each classification were then randomly divided into two groups of four subjects each. Finally, the average response for the subject groups on each variable was calculated giving a 24 x 75 (subject -group x items) response matrix.
2. The 24 x 75 response matrix was transposed to yield a 75 x 24 (items x subject-groups) matrix.
3. The scores (means) in each row of the matrix were transformed to z-scores in order to bring them to a common metric or scale.
4. All possible intercorrelations were then calculated for the 24 columns of this matrix, resulting in a 24 x 24 correlation matrix.
5. The correlation matrix was then subjected to unrotated principal components analysis.
6. An oblique transformation by the Procrustes method

(Hurley and Cattell, 1962) was then performed on the three principal components with eigenvalues greater than one in an attempt to match a hypothesized pattern matrix. The best fitting (most interpretable) factor pattern was then chosen as defining the Q-subscales.

7. Factor scores were obtained for each of the Q-subscales on all of the seventy-five variables in the SBQH.

The FACT 08 program from the DERS library was used for the calculations. It is based on a procedure elaborated by Harman (1960). The basic equation for the procedure is:

$$F = S^{I} R^{-1} Z$$

where F (r x N) is the factor score matrix; S (n x r) is the factor structure matrix; R (n x n) is the correlation matrix among the variables; and Z (n x N) is the matrix of standardized scores for n variables, r factors, and N persons. Factor scores of ± 1.30 or greater were arbitratily taken as indicating that an item should be included in a particular Q-aptitude.

8. Finally, each subject was scored on the items representing a particular Q-aptitude and the scores were standardized to be used as the measure of the amount of aptitude possessed by each student for the correlational and analyses of variance procedures.

Table 3 is a summary of the subject-groups used in subsequent analyses classified according to their group number.

The factor pattern used to define the Q-subscales, together with the hypothesized pattern matrix, are given in Table 4.

In the target matrix used, separate high and low performance styles were hypothesized as well as a separate experimental school combination of aptitudes. The separate high and low styles have implications with regard to the SCAT quantitative scale. If they are independent of the SCAT score, then they may define an information processing style which might lead to ATI. Another possibility is that they are specific to the nature of the performance being tested. If this is the case, then it is unlikely that they will lead to interactions when a single performance criterion is used to measure the outcomes of the two different treatments.

The target presented in Table 4 was not the only one used. Separate school targets were tested, but found inadquate. Also, the hypothesis of a bipolar ability factor nested within the schools was tested. Again, the results of the factor pattern did not support the hypothesis. The final target chosen was suggested by the results of an exploratory VARIMAX rotation of the three principal components that resulted from the components analysis. By removing the restriction of complete orthogonality from the structure, the

TABLE 3

Group Identification Numbers Used in Q-Analysis

School	Sex	Biology Test Results		
		Hi	Med	Low
Cont.	M	1.2	3.4	5.6
	F	7.8	9.10	11.12
Expt.	M	13.14	15.16	17.18
	F	19.20	21.22	23.24

TABLE 4

Target and Pattern Matrices Used to Define Q-Subscales

Group No.	Hypothesized (H) and Observed (O) Q-Factor Loadings					
	Q1-H	Q1-O	Q2-H	Q2-O	Q3-H	Q3-O
1	1.0	.86	0.0	-.09	0.0	.07
2	1.0	.72	0.0	-.00	0.0	-.07
3	0.0	.47	0.0	.26	0.0	.47
4	0.0	.88	0.0	-.25	0.0	.11
5	0.0	-.37	1.0	1.02	0.0	.04
6	0.0	.28	1.0	.60	0.0	.08
7	1.0	.60	0.0	-.06	0.0	.61
8	1.0	.89	0.0	-.07	0.0	.11
9	0.0	.64	0.0	.17	0.0	.22
10	0.0	.37	0.0	.43	0.0	.29
11	0.0	.12	1.0	.64	0.0	.23
12	0.0	-.05	1.0	.81	0.0	.33
13	1.0	.90	0.0	-.28	1.0	.23
14	1.0	.62	0.0	.13	1.0	.36
15	0.0	.15	0.0	.58	1.0	.44
16	0.0	.29	0.0	.05	1.0	.80
17	0.0	-.49	1.0	.73	1.0	.58
18	0.0	.12	1.0	.36	1.0	.53
19	1.0	.67	0.0	-.10	1.0	.52
20	1.0	.55	0.0	.22	1.0	.21
21	0.0	.23	0.0	.48	1.0	.47
22	0.0	.41	0.0	.25	1.0	.52
23	0.0	.21	1.0	.54	1.0	.47
24	0.0	-.12	1.0	.81	1.0	.42

oblique pattern showed a larger number of high loadings and included more of the subject-groups in each of the Q-factors. Since there is not reason to suppose that the components of an information processing style should be independent, this last structure (Table 4) was chosen as defining the Q-aptitudes.

The items from the SBQH selected to represent each of the Q-subscales are presented in Table 5. A negative sign preceding the item indicates that it is to be reverse scored to determine its contribution to the final aptitude.

Seven items are common to both the Q1 and Q2 subscales. However, in all cases they are scored in the opposite direction from Q1 for the Q2 case. This gives a degree of validity to the assumption that these two subscales are measuring different student information processing styles. As an example, consider question #1: "I think that most people can actually learn better when they are given the facts about a subject instead of having to figure them out by themselves (Appendix C)." The students with the highest Biology 20 performance disagree with this assertion. Rote factual learning apparently is not part of their preferred information processing strategy. The poorer students agree with the statement.

On the basis of what they appear to be representing the Q1, Q2, and Q3 subscales were labelled High Performance Strategy, Low Performance Strategy, and Experimental School Strategy respectively. Further discussion of the nature of

TABLE 5

SBQH Items Included in the Q-Subscales

Subscale	Items Included in Subscale
Q1	-1 2 -5 11 -14 15 21 -23 -25 -28 -32 39 44 -46 -50 53 57 65 66 -68
Q2	1 5 7 -11 -20 -21 23 28 32 34 -35 -36 -38 -40 -42 -51 -60 61 -69 -75
Q3	-5 8 12 15 17 -21 -24 -28 -31 35 -39 46 -60 -64

the Q subscales and their relationship with the SBQH subscales is found in the correlations which follow.

Correlations

Relationships among sex, SCAT verbal, SCAT quantitative, Biology 20, SBQH subscales, and Q subscales were determined by computing the Pearson product-moment intercorrelation matrix for these variables. This was done separately for the two groups and repeated on the sample with the groups combined. The results of the analyses are presented in Tables 6, 7, and 8. Results which are significant at the .05, .01, and .001 levels are indicated by single, double, and triple asterisks respectively. All correlations discussed in the sections which follow were significant at the .05 level or beyond.

The SCAT quantitative score correlates with Biology 20 performance for both the experimental (.43) and control (.41) groups. In the Control group, but not in the Experimental, it is also related to the SCAT verbal score (.46) and the Instrumental Motivation subscale of the SBQH, (.28).

Performance on the criterion test is related to the SCAT score results for both groups. There is also a common negative correlation (-.34 and -.35 for the control and experimental groups respectively) with the Academic Neuroticism subscale. For the Experimental group performance on the criterion was also correlated positively

Table 6

Experimental Group: Intercorrelations Among All Variables

Variable	Sex	S-V	S-Q	B20	F-R	SKO	I M	M A	A N	A M	T A	I-E	Dep	Q 1	Q 2	Q 3
Sex	100															
S-V	14	100														
S-Q	-20	19	100													
B20	01	45***	43***	100												
F-R	15	-05	01	03	100											
SKO	10	05	06	10	-05	100										
I M	01	-07	21	04	34**	42***	100									
M A	00	33*	15	10	00	49***	29*	100								
A N	03	-06	-14	-35**	26*	-18	07	-01	100							
A M	11	14	16	35**	01	24	39**	35**	16	100						
T A	12	-03	-03	04	47**	11	40**	-01	30*	27*	100					
I-E	02	32*	-02	-02	06	34**	34**	63***	19	46***	17	100				
Dep	04	10	06	04	43***	43***	45***	37**	12	14	36**	25	100			
Q 1	01	06	09	14	-52***	29*	-12	08	-55***	-03	-35**	15	-20	100		
Q 2	01	-14	-13	-16	-14	-54***	-35**	-57***	-28*	-58***	01	-44***	-36**	21	100	
Q 3	05	-07	-19	-16	-51***	-24*	-61***	-35**	-24*	-46***	-38**	-28*	-30*	47***	61***	100

*p< .05 **p< .01 ***p< .001 All entries in the table are multiplied by 100.

Table 7

Control Group: Intercorrelations Among All Variables

Variable	Sex	S-V	S-Q	B20	F-R	SKO	I M	M A	A N	A M	T A	I-E	Dep	Q 1	Q 2	Q 3
Sex	100															
S-V	-28*	100														
S-Q	-07	46***	100													
B20	-13	52***	41***	100												
F-R	-07	-17	16	-21	100											
SKO	-03	-10	12	16	07	100										
I M	09	07	28*	-05	07	42***	100									
M A	09	-09	-15	-16	-04	50***	42***	100								
A N	03	-35**	13	-34**	40**	06	05	07	100							
A M	08	01	-01	19	-33**	60***	32*	55***	-22	100						
T A	-02	-26	-15	-39**	21	35**	33*	32*	57***	14	100					
I-E	06	09	-09	04	-08	32*	08	56***	-16	52***	05	100				
Dep	06	-03	-06	-15	20	33*	36**	42***	31*	28*	41**	37**	100			
Q 1	-02	37**	14	44***	-46***	-03	00	-13	-82***	27*	-50***	11	-19	100		
Q 2	-06	19	14	-05	-06	-64***	-21	-61***	-05	-73***	-14	-54***	-40**	16	100	
Q 3	-03	21	-12	04	-12	-42***	-53***	-25	-24	-40**	-35**	03	-17	23	41***	100

*p< .05 **p< .01 ***p< .001 All entries in the table are multiplied by 100.

Table 8

Combined Groups: Intercorrelations Among All Variables

Variable	Sex	S-V	S-Q	B20	F-R	SKO	I M	M A	A N	A M	T A	I-E	Dep	Q 1	Q 2	Q 3
Sex	100															
S-V	-09	100														
S-Q	-13	36***	100													
B20	-03	46***	39***	100												
F-R	04	-11	09	-10	100											
SKO	03	-03	09	13	01	100										
I M	05	02	25**	-02	20*	42***	100									
M A	04	11	-01	-03	-02	49***	35***	100								
A N	03	-22*	-13	-34***	-33***	-06	06	03	100							
A M	09	07	07	26**	-15	42***	36***	45***	-03	100						
T A	05	-14	-09	-18*	35***	23*	37***	14	43***	21*	100					
I-E	04	20*	-05	01	-01	33***	22*	60***	02	49***	12	100				
Dep	05	03	00	-06	32***	38***	40***	39***	22*	21*	38***	30***	100			
Q 1	00	22*	11	30***	-49***	13	-06	-02	-69***	11	-42***	13	-20*	100		
Q 2	-02	03	01	-10	-10	-59***	-28**	-59***	-17	-65***	-06	-48***	-38***	18	100	
Q 3	01	08	-15	-05	-32***	-33***	-57***	-30***	-24**	-43***	-37***	-13	-24*	35***	51***	100

*p< .05 **p< .01 ***p< .001 All entries in the table are multiplied by 100.

(.35) with Academic Motivation. Test Anxiety was negatively correlated (-.39) with performance while the Q1 subscale showed a positive correlation (.44) with it within the control group.

The Q1 aptitude or information processing style shows similar patterns of correlations in both groups of subjects. It is negatively correlated with the Fact-Rote, Academic Neuroticism and Test Anxiety SBQH subscales. In the experimental sample there is also a significant positive correlation (.29) with the Study Skills and Organization subscale.

Both the Q2 and Q3 subscales show similar patterns of correlations in the experimental and control samples. Neither correlate with performance on the Biology 20 test nor with SCAT type academic ability. The Q2 style, which cuts across schools, is apparently a study behavioural strategy favored by non-academic types of students. The Q3 subscale shares some common aspects with the Q2 ($r = .51$, $p < .001$), but is not a strategy restricted to the non-academic student. Instead, it may be a study behavioural strategy which is produced by the instructional conditions in the experimental school.

The SBQH subscales show varying degrees of dependence among themselves. This is largely a result of the way in which they were formulated. It is also apparent that they are measuring characteristics of the students that are not related to their cognitive type abilities.

For a more general look at the relationships in question both samples were combined and subjected to a

common analysis. The results and discussion which follow apply to the combined sample.

None of the correlations involving sex are significant. This indicates that the type of aptitudes measured by the SBQH are not sex specific. For this reason, sex was not considered as a variable in any of the analyses of variance.

Both the SCAT verbal and quantitative subscales correlate with performance on the Biology 20 test. However, they are nearly independent of the SBQH subscales and the Q subscales. The SCAT quantitative score correlates only with the Instrumental Motivation subscale (.25). It appears, therefore, that the types of aptitude which the questionnaire measures are genuinely independent of cognitive type ability measures.

Performance on the Biology 20 test correlates positively (.26) with the Academic Motivation subscale and negatively with the Academic Neuroticism (-.34) and Test Anxiety (-.18) subscales. These relationships are in the expected direction.

Correlations involving the Q-subscales are quite revealing. Q1 correlates negatively with the Fact-Rote (-.49), Academic Neuroticism (-.69), Test Anxiety (-.42), and Dependence (-.20) subscales. In addition it is related (.30) to success in the Biology 20 cognitive test. It apparently distinguishes a combination of aptitudes or information processing style which leads to superior academic performance, independently of the instructional setting.

The Q2 subscale correlates negatively with the Study

Skills and Organization, Instrumental Motivation, Meaning Assimilation, Academic Motivation, Internal-External and Dependence subscales. The correlation between Q2 and Biology 20 is not significant. Students high in Q2 do not appear to have an academic orientation.

Correlations involving the Q3 subscale give it additional dimensions compared to the Q2. It is related to all of the same SBQH subscales as Q2, except for the Internal-External one. In addition it correlates negatively with the Fact-Rote, Academic Neuroticism, and Test Anxiety subscales and positively with the Q1 type of study behaviour strategy. A check back to the separate group correlations (Tables 6 and 7) indicates that these relationships are most pronounced for the experimental group.

Apparently the Q3 strategy indicates a type of study behaviour style which, although not related to academic performance, is relatively common among students. It represents a type of student who is low on motivation, organization, neuroticism, test anxiety, and oriented towards external standards while at the same time maintaining his independence in the educational setting and learning by other than a fact-rote strategy. It could be picking out the student who has become indifferent to school and its pocesses. Probably the relationship between Q1 and Q3 is accounted for by the fact that both strategies rely on other than a fact-rote method of learning, are low on academic neuroticism and test anxiety, and able to function independently in the

educational environment.

Analysis of Variance

A series of three-way Analyses of Variance using the DERS ANOV88 program were carried out to determine main effects and interactions involving the students' performance on the Biology 20 criterion test. The sample was divided on the basis of schools and three levels each of SCAT quantitative ability and SBQH or Q aptitudes. To give an equal number of subjects in each cell, an additional forty subjects were randomly discarded from the sample; sixteen from the control group and twenty-four from the experimental. The total number of subjects involved in each analysis of variance was one hundred and eight. Each cell contained six subjects in the final data matrix.

A total of twelve different analyses of variance were carried out, each using a different SBQH or Q subscale as an independent variable. A significant main effect due to SCAT quantitative ability was obtained in all analyses of variance ($p < .001$). Only two of the analyses had additional significant results. Summaries of the results for these are given in Tables 9 and 10. A complete report of the rest of the analyses is given in Appendix F.

The results of the F tests for the analysis of variance involving the SBQH Internal-External subscale indicate a significant main effect due to schools ($F = 4.19$, $df = 1,90$, $p < .05$). The means were 21.1 and 22.8 for the control and experimental groups respectively.

TABLE 9

Summary of Analyses of Variance among Schools, SCAT Quantitative Ability and Internal-External

Source of Variation	df	Mean Score	F
A. Schools	1	75.00	4.186*
B. SCAT Quantitative	2	267.06	14.904***
AB. Schools x SCAT Q.A.	2	4.19	0.234
C. Internal-External	2	34.95	1.951
AC. Schools x I.E.	4	18.69	1.043
BC. SCAT Q.A. x I.E.	4	26.54	1.481
ABC. Schools x SCAT Q.A. x I.E.	4	59.06	3.296*
WITHIN CELL	90	17.92	

*$p<.05$
**$p<.01$
***$p<.001$

TABLE 10

Summary of Analyses of Variance Among Schools, SCAT Quantitative Ability and Dependence

Source of Variation	df	Mean Square	F
A. Schools	1	75.00	4.294*
B. SCAT Quantitative Ability	2	267.06	15.290***
AB. Schools x SCAT Q.A.	2	4.19	0.240
C. Teacher Dependence	2	21.15	1.211
AC. School x Teacher Dependence	2	119.44	6.838*
BC. SCAT Q.A. x Teacher Dependence	4	6.52	0.373
ABC. Schools x SCAT Q.A. x Teacher Dependence	4	45.76	2.620*
WITHIN CELL	90	17.47	

*$p<.05$
**$p<.01$
***$p<.001$

None of the analyses of variance indicated a main effect due to either the SBQH or the Q aptitudes. This is in agreement with the correlational data which showed only scattered relationships among SBQH subscales and the criterion scores. The absence of main effects here is not so important, however, since the objective of the study is to find interactions between the SBQH or Q aptitudes and the treatments.

A second significant result involving this subscale was a three-way interaction among Schools, SCAT ability, and the Internal-External subscale. Table 11 is a summary of the cell means involved in this interaction. A plot of the means is given in Figure 2 for each level of SCAT ability.

The results of the plots in Figure 2 indicate that students with medium amounts of SCAT ability and those with medium quantities of internal direction are least affected by the instructional environments. Low SCAT ability, low internals (high externals) appear to perform better under the experimental conditions and poorly in the control setting. For the high SCAT ability student, it appears that the main differential effect is for those who have medium internal-external direction. These perform better in the experimental setting (mean = 28.5) and poorer in the control setting (Mean = 21.8). Students with both high SCAT and high internal direction do relatively well under both situations.

TABLE II

Summary of Cell Means for Analysis of Variance Among Schools, SCAT Quantitative Ability and Internal-External

	SCAT Ability	Internal-External High	Med	Low
CONT	Hi	27.7	21.8	23.4
	Med	19.8	19.7	22.2
	Lo	21.5	17.5	16.3
EXPT	Hi	24.8	28.5	23.3
	Med	22.3	22.0	21.5
	Lo	22.0	17.0	23.4

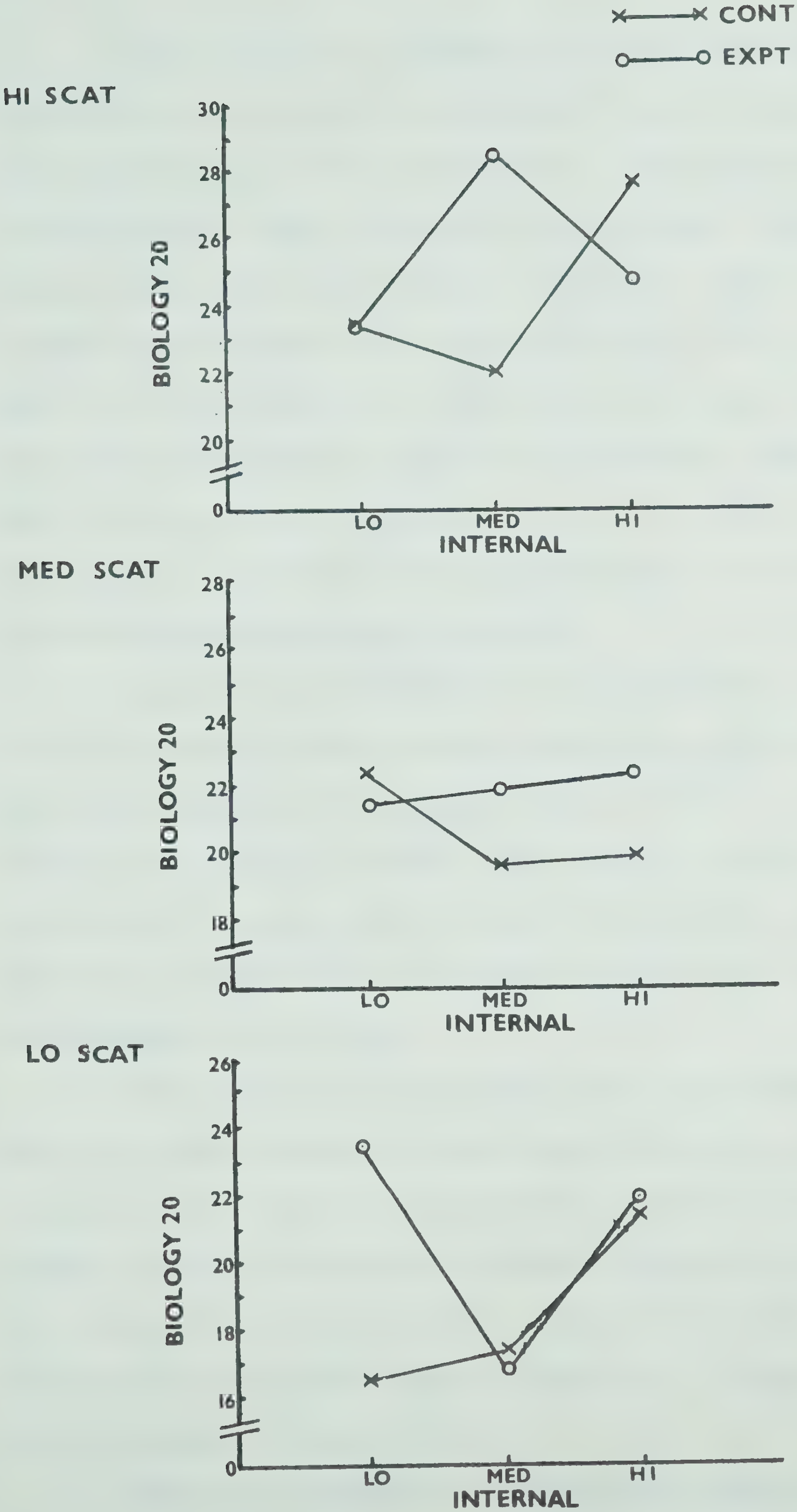

Figure 2 Interaction Between Treatments and Internal-External Subscale Within Levels of SCAT Ability

The results for students with low SCAT ability are not surprising in view of the different instructional emphasis represented by the two treatments. The experimental situation is designed so that a low ability, external type student can secure extra help and teacher direction. Also, he is allowed to progress at a self-determined rate. In the control setting this student will have more difficulty obtaining individual attention, and he is expected to keep up with the rest of the class. Consequently, he is likely to experience feelings of frustration and helplessness which are unlikely to encourage optimum performance.

Experimental students with intermediate amount of internal-external directedness and high SCAT ability have the best performance of any group (mean = 28.5). A possible reason for this may be that they have a kind of optimal amount of the aptitude and this allows them to make maximum use of both the freedom and individual teacher help that the treatment environment can provide.

The analysis of variance involving Schools, SCAT ability, and Dependence shows significant main effects involving SCAT ability and Schools. There is also a significant two-way interaction between Schools and Dependence ($F = 6.84$, $df = 2,90$, $p < .05$). Means involved in this interaction are summarized in Table 12. Figure 3 is a plot of the two-way interaction.

Scheffe a posteriori comparisons among these cell means indicate that:

TABLE 12

Summary of Means Involved in Schools x Dependence Interaction

School	Dependence High	Med	Low
Control	19.2	22.5	21.7
Experimental	24.2	20.3	23.9

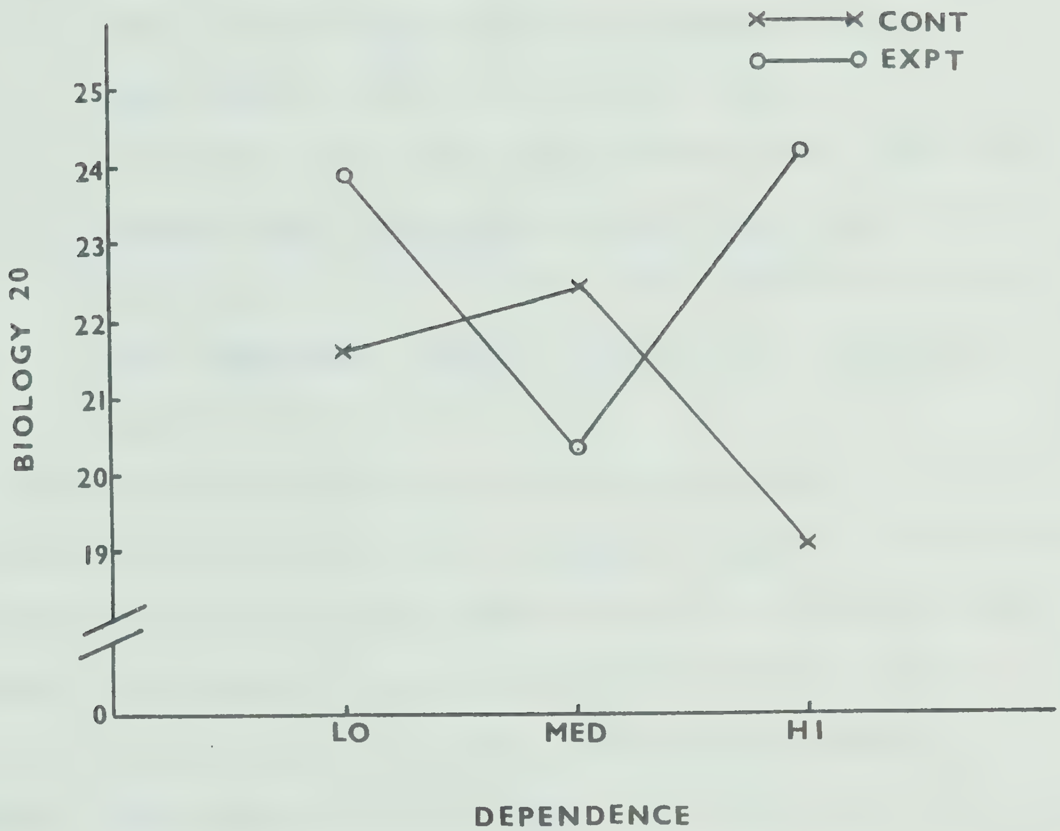

Figure 3 Treatments x Dependence Interaction

(1) students within the experimental group who are high on dependence perform significantly better (mean = 24.2) than control group students with high dependence (mean = 19.2);

(2) for the low and medium levels of dependence, there are no significant differences between the experimental and control group; and,

(3) students within the experimental group that have medium levels of dependence perform significantly more poorly (mean = 20.3) than those with either high dependence (mean = 24.2) or low dependence (mean = 23.9).

These results indicate an interaction effect which fits under the preferential paradigm. Students high in dependence can apparently function best under the kind of instructional environment provided by the experimental setting. Again, this is not surprising since such a student can spend a relatively large amount of his class time obtaining direct teacher help. In the control setting this is not as likely to occur. Consequently, this type of student may not perform as well.

There was also a significant three-way interaction involving Schools, SCAT ability, and Dependence. Table 13 is a summary and Figure 4 is a plot of the cell means involved in this interaction. Figure 4 reveals, that for students with medium levels of SCAT ability, dependence appears to have no differential effect on performance. However, students with

TABLE 13

Summary of Cell Means for Analysis of Variance Among Schools, SCAT Quantitative Ability and Dependence

	SCAT Ability	Teacher Dependence High	Med	Lo
CONT	Hi	21.7	27.0	24.5
	Med	19.7	20.2	21.8
	Low	16.2	20.3	18.8
EXPT	Hi	29.2	20.3	27.2
	Med	20.7	22.2	23.0
	Low	22.7	18.3	21.7

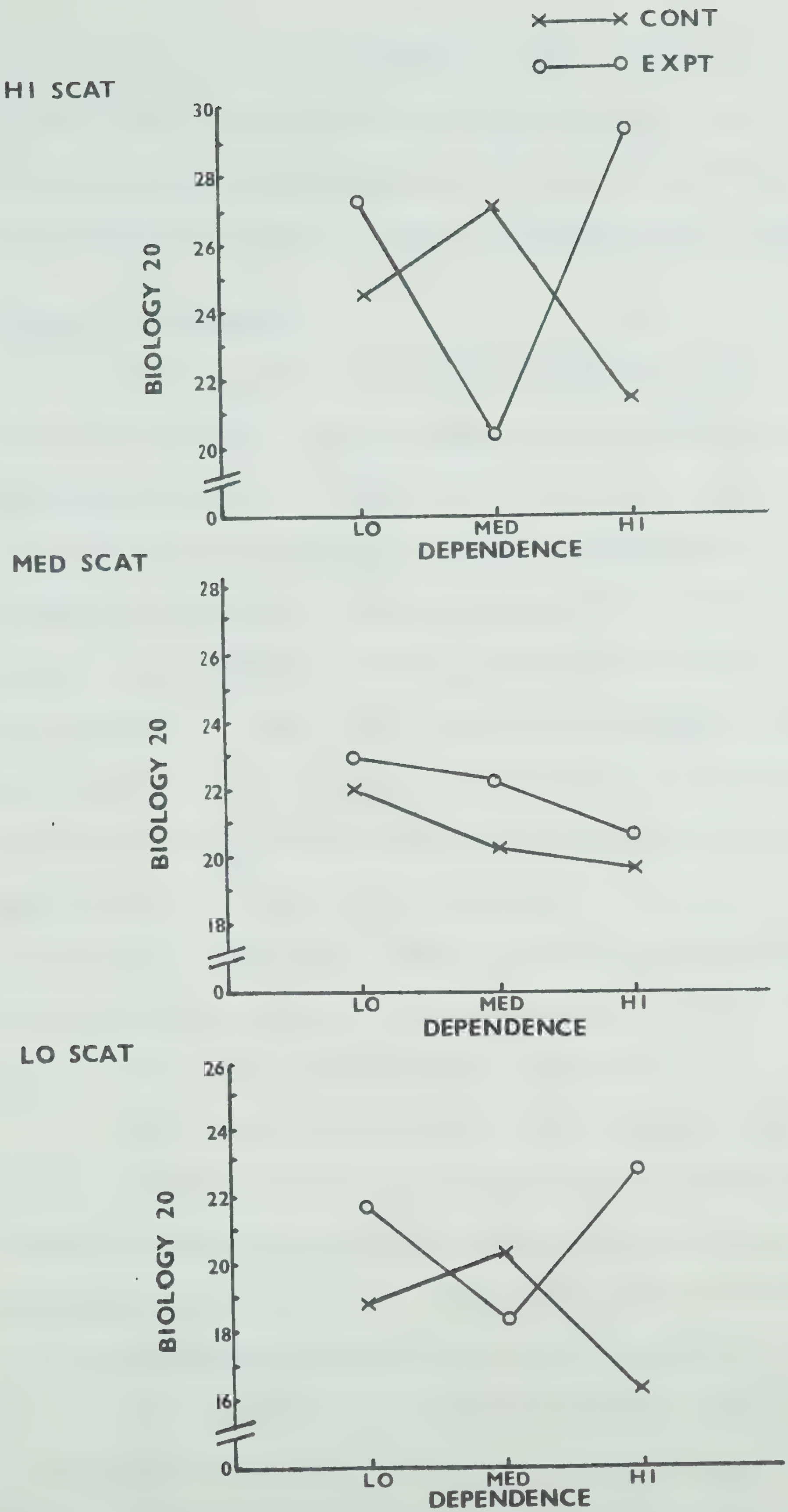

Figure 4 Interaction Between Treatments and Dependence Subscale Within Levels of SCAT Ability

either high or low dependence show relatively similar patterns within both the control and experimental setting. Students with high dependence apparently perform better in the experimental situation than in the control setting.

Summary of Results

The results involving the Q subscales indicate that, at least in this study, these kinds of complex study behaviours are not useful aptitudes for detecting ATI. Apparently the types of aptitudes making up a Q-scale are too general in nature. The strategies of the Q1 and Q2 subscales seem to be characteristics of two distinctly different kinds of students. Also, they appear to be quite independent of particular instructional environments. It appears that these aptitudes are a relatively stable collection of behaviours and are not simply thrown together in order to respond to a particular treatment. This is not entirely clear, however, since the Q3 subscale characteristics seemed to be largely confined to the experimental subjects.

SCAT quantitative ability, as expected, was shown to have a general effect on performance. Those students with highest SCAT ability performed consistently better than students with medium or low amounts of this aptitude in both the experimental and control environments.

The results involving the schools are rather ambiguous. It appears that both treatments produce about the same levels of performance. However, two of the results indicated a significant difference in favor of the experimental school.

These are probably best explained as reflecting a bias built into the test since it was constructed by the teachers from the experimental school.

Only two of the subscales from the SBQH produced significant interactions. The interaction involving Schools, SCAT ability, and the Internal-External subscale indicates two differential effects. For the low SCAT ability, high external student, performance was significantly better under the experimental treatment. This indicates that such students do receive more individualized instruction in the experimental setting than in the control situation. High SCAT ability students, with neither a pronounced internal nor external bias, were also found to perform better under the experimental treatment. There is no apparent explanation why this should occur.

The two-way interaction involving Schools and the Dependence subscale indicates that the experimental environment allows both the dependent and independent student to perform well. This result was to be anticipated since the former type of student can receive extra teacher attention while the latter type can be left largely on his own. The fact that highly dependent students perform poorly in the control setting may be an indication that they are unable to receive sufficient individual attention. The three-way interaction indicates that this dependence effect is particularly true for the dependent students having either high or low SCAT ability. Dependence does not seem to affect the performance

of the student with average SCAT ability.

In the cases where the interactions occurred, the relationship between the SBQH aptitude and ability do not seem to be linear. Instead the study behavior aptitude appears to exert more influence on the performance of students having the extremes in SCAT ability. These results give some support to the preferential model for ATI.

Three other SBQH aptitudes which were postulated to be important sources of ATI gave no significant interactions between treatments and their particular aptitude. It appears that Fact-Rote, Meaning Assimilation, and Academic Neuroticism are either not important, or, are equally important in determining performance under both treatments.

The basic hypothesis examined by this study receives only tentative support from the results of the analyses. There is evidence that the SBQH did measure important student study behavior characteristics and that the instructional treatments were different. However, the hypothesis that the study behavior strategies would lead to differential levels of academic performance under the different treatments is only supported in two out of a possible eight cases where it was expected to occur.

The hypothesis that Q-technique can provide a method of classifying subjects that will make the detection of ATI easier received no support from the results.

Chapter 5

Conclusions

The two aptitudes which were involved in ATI's in this study were both unidimensional SBQH ones. None of the multidimensional Q-aptitudes showed any evidence of interactions. These results indicate that Q-technique is unlikely to provide a useful way of defining an ad hoc collection of items which represents a significant source of differential performance among students as a function of treatments. It thus appears that the Q-technique is probably not an adequate alternative approach to the problem of finding aptitudes that will fit within an ATI paradigm.

As Cronbach (1967) pointed out, it thus seems that simple unidimensional aptitudes offer most promise for defining significant interaction effects. The study behaviour characteristic measured by the Internal-External subscale, for example, should be an important factor in determining performance in an unstructured educational environment. The degree of structure is one of the most important differences between alternative educational settings. It would appear, therefore, that if the treatment could be classified as to amount of structure, and the student classified as to the amount of internality, then differential assignment of students under a preferential paradigm should be possible. The results of this study give some evidence to support this

assertion, at least, for the case of the student with low academic ability.

A similar argument can be presented for the Dependence aptitude; in fact dependence is an aptitude specifically mentioned by Cronbach (1967) as being a likely one in ATI. Thus, dependence should result in differential performance as a direct function of the amount of individual attention which the student can receive from the teacher. Under a preferential model, the dependent student should be placed in an environment where he can receive lots of attention. The performance of dependent students in the experimental treatment investigated in this study supports this idea.

It seems apparent that the most promising study behaviour aptitudes for detecting ATI are those that can be related to particular distinguishing characteristics of the educational treatment. For example, the degree of student dependence appears to be important in situations where there are differing amounts of time for individual student-teacher contact. The Internal-External aptitude can be related to the degree of structure imposed by the treatment. This would indicate a definite need to characterize instructional treatments on as many variables as possible. Then those characteristics on which the treatments differed could be selected for matching with particular study behaviour aptitudes.

If the paradigm outlined above works then a possible reason why more interactions were not found in this study was the fact that the treatment environments were not

studied prior to selecting the study behaviour aptitudes used. It now seems apparent that simply classifying a particular environment as innovative or experimental can not assure differences in instructional techniques that will lead to interactions with any general set of a priori aptitudes.

This study provides some evidence that student study behaviour aptitudes, which are independent of academic ability, can be measured. Further, there is an indication that such aptitudes can lead to differential performance under the preferential paradigm for ATI. It therefore appears that further studies in this area might discover a series of aptitudes which could be used for matching students to particular environments on the basis of certain distinguishable characteristics of the environment in question.

A significant variable not specifically examined in this study was that of teacher "teaching styles". It is entirely possible that variations in such teaching behaviours could have accounted for more variation in student performance than the difference in the instructional objectives and emphasis between the two treatments.

There appear to be several steps that should be followed by any future studies aimed at detecting ATI in an instructional setting. These are as follows:

(1) There should be a careful examination of the similarities and differences in the stated objectives of the alternative treatments.

(2) An analysis of the treatment environments directed towards classifying significant differences between them should be made. The objective would be to develop a taxonomy of environmental characteristics which could be matched with aptitudes in an effort to design interactions.

(3) Only those aptitudes which can be related to distinguishing characteristics of the environments or teaching styles should be measured.

(4) The role of the teacher in each treatment should be contrasted and compared. All individual differences in "teaching behaviour" would be noted.

(5) The criterion measure should be designed specifically to measure those cognitive outcomes specified as the major instructional objectives by the treatments.

An approach such as the one outlined should enable further significant aptitudes to be isolated. This in turn will allow a better matching of the individual student to a particular instructional treatment.

Another problem which future research must consider is the degree to which any aptitude can be modified by the instructional treatments. If it is found that modification of aptitudes is not possible, then the basic strategies for individualizing teaching become the preferential and

compensatory models. However, if the treatment is found to modify aptitudes, then the optimal match-mismatch type of paradigm will have to be developed in order to allow best student performance.

In conclusion, it appears that this study has given one indication of an area where future research might find more instances of ATI. It has also shown the apparent futility of attempting to classify students on an ad hoc basis for purposes of detecting ATI.

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APPENDIX A

OBJECTIVES - Biology 10 - 20 Project

OBJECTIVES - Biology 10 - 20 Project

Program objectives for our Biology 10 - 20 Project at McNally can be divided into 3 categories: Affective, cognitive and evaluative.

AFFECTIVE CATEGORY

In the affective domain the objective is to arrange a learning situation which will allow the student to:

(a) Progress through a course according to his individual capabilities, interests and aptitudes (within reasonable limits)

(b) Develop responsibility, initiative and confidence

(c) Experience a wide variety of information sources and instructional materials

(d) Experience a satisfying, informative, enjoyable teacher-student relationship

(e) Improve attitudes towards school and learning in general

COGNITIVE CATEGORY

1. To provide the student with a background knowledge in the following biological subjects:-

(a) MICROSCOPY AND CYTOLOGY

The student must be able to demonstrate correct use of the compound microscope, prepare temporary microscopic mounts, and outline the differences between plant and animal cells.

(b) TAXONOMY

The student must be able to demonstrate a basic knowledge of taxonomy so that he is able to classify organisms to kingdom and phylum and further if a dichotomous key is present.

(c) ECOLOGY

The student must be able to define ecology, outline the abiotic and biotic components of ecosystems, and state the significance to ecology of the following aspects: Ecosystem, Community, Biogeography, Populations, and Carrying Capacity.

(d) ENVIRONMENTAL PROBLEMS

The student must be able to list four major current biological problems: outline the problem in ecological terms and state the steps that are being taken or those that should be taken to alleviate these problems.

(e) HEREDITY

The student must be able to: identify and describe the steps involved in the processes of meiosis, state and give examples of Mendels Laws and use Punnett squares to illustrate various crosses.

(f) EVOLUTION

The student must be able to outline Lamarck's, Darwin's and the modern theories of evolution and outline the mechanism by which new species are formed.

(g) PLANT AND ANIMAL MORPHOLOGY

The student must be able to

(a) state the developmental trends present in representatives of Protista, Invertebrata, and Vertebrata, and compare and contrast the differences and similarities of the structures concerned with nutrition, development, excretion, circulation, respiration, interpretation of nervous stimuli and reproduction.

(b) state the developmental trends present in representatives of simple (nonvascular) plants and complex (vascular) plants and compare and contrast the differences and similarities of the structures involved in photosynthesis, transport of materials, respiration, reproduction, excretion and acquisition of materials.

II. To allow a student, via lab and field oriented activities, an opportunity to experience the methods a biologist employs in his research.

III. EVALUATIVE CATEGORY

To enable the teacher through an individualized approach to evaluate more effectively the needs of each individual student. This provides a learning experience that allows for maximum development of the student in both affective and cognitive domains.

APPENDIX B

BASIC ECOLOGICAL PRINCIPLES

(Botany or Zoology)

Point Value: 14

M. Ballash, R. Makowecki, S. Eliuk, P. Harris, C. Kachman.
McNally Composite High School, Edmonton, Alberta, 1970, 2nd Edition.

OVERVIEW

Ecology is the science which deals with the inter-relationships existing between various groups of organisms and between all living forms and the nonliving environment. Because it includes all living and nonliving entities on the earth, its scope is widest of all the sciences and it draws material from zoology, botany, entomology, limnology, parasitology, anatomy, physiology, topography, metereology, geology, physics, and chemistry.

Ecology today has taken on new importance. The ever-increasing human population now endangers the relationships existing between organisms and their environments by exploiting these environments for human use. Working in co-ordination with those involved in water resources, agriculture, recreation and education the ecologist attempts to find answers to and at the same time preserve natural resources through pollution problems, wildlife management and preservation.

MAJOR BEHAVIOURAL OBJECTIVES

Upon completion of this unit the student must be able to state what ecology is and what parts compose the abiotic and biotic components of ecology. Also the student must be able to state the meaning of biogeography, ecosystem, carrying capacity, populations and indicate their importance to ecology.

LESSON I

BEHAVIOURAL OBJECTIVES

1. The student must be able to define ecology.

The science of ecology includes studies of all living (biotic) and non-living (abiotic) structures on the earth's surface. The world is not static. That is all life activities strive to maintain a balance or a steady state. This balance involves two aspects: Energy and matter.

Energy is involved with the biotic component of the earth. Ultimately all energy used by biotic forms is derived from the sun.

2. The student must be able to define the following terms: producer, primary consumer, secondary consumer, tertiary consumer, saprovore, (decomposer).

All existing protoplasm is directly or indirectly a result of the energy of sunlight passed from one organism to another.

3. The student must be able to:

   a. Define the terms: food, food chain, food web, food pyramid.

   b. Give an example of one aquatic and one terrestrial food chain in Alberta.

Abiotic factors include such aspects as climate, soil, water and minerals. The sun's energy is used in converting matter (water and minerals) into a form usable by living organisms. Organisms are therefore made up of chemical material that make up the rest of the world. The amount of this matter is finite and therefore elements and energy must circulate through the environment.

4. The student must be able to outline from memory the following cycles:
   a. carbon
   b. water
   c. nitrogen
   d. calcium

5. The student must be able to differentiate between organic and inorganic compounds.

For ease of communication ecologists have coined terms to indicate or name groups of organisms existing together.

6. The student must be able to define the following terms: population, community, ecosystem, biosphere.

An environment is never static. As plant populations inhabit an area, specific animal populations follow. Natural changes in plant populations thus necessarily mean a change in the associated animal populations.

7. The student must be able to:

    a. Define ecological succession, pioneer community, and climax community.

    b. Using bare rock as a starting point outline an entire ecological succession as might be found in Alberta in the correct sequence.

8. The student must be able to state the relationships that exist between plants and animals in terms of photosynthesis and respiration.

LEARNING MATERIALS AND ACTIVITIES

1. Read and make notes from

   a. BSCS Green Version, Chapter 1, pp. 2-5
      pp. 18-26
      pp. 28-34
      pp. 92-98

   b. Modern Biology, pp. 660-670

   c. BSCS Blue Version, pp. 721-744

2. Carry out Lab Activity 1:5 (BSCS Green text) page 26, or BSCS Lab Manual Activity 1:3. Included in the laboratory write-up should be a full analysis of the results. Questions in the 'discussion' section of the lab activity will be valuable in the analysis of the results.

3. Look at the following filmstrips;

   a. Introduction to Ecology

   b. Physical Environment

   c. Changes in Ecosystems

   d. Ecological Succession

4. Attend review lecture.

SELF TEST

1. Define:

   a. producer

   b. consumer

   c. saprovore

   d. food web

   e. population

   f. ecosystem.

2. Outline the water cycle and the carbon cycle.

3. Define ecological succession and using bare rock as an example outline the succession which occurs.

QUEST

LESSON II

BEHAVIOURAL OBJECTIVES

The study of ecology is intricately involved in the practicies of wildlife management and conservation. Ecological principles involved in the interactions between animals and plants in the natural state must be understood if ecologists are to manage wildlife populations in the limited natural environment remaining today. In this respect, the ecologist is primarily concerned with population and habitat.

1. The student must be able to define and state examples of the following terms: habitat, ecological niche, carrying capacity and population density.

Population size in any natural environment fluctuates because of interactions between organisms and interactions between organisms and the environment.

2. The student must be able to:

   a. explain how the following factors determine population fluctuations: mortality, natality, immigration, and emigration.

   b. define the following terms: predation, parasitism, commensolism, mutualism, intraspecific competition and interspecific competition.

   c. state what effect the following aspects have on population fluctuation: nutrients, space to live, climate, and density.

3. The student must be able to draw and describe a population growth curve.

LEARNING MATERIALS AND ACTIVITIES

1. Read and make notes from

   a. BSCS Green Version, pp. 36-43
   pp. 47-52
   pp. 56-61
   pp. 83-89

   b. Modern Biology, pp. 672-680

2. View the following filmstrips:

   a. Habitats and Niches

   b. Populations and Biomass

3. Carry out the Lab Activity (with a partner) as indicated in Appendix I.

4. Attempt review lesson on Population Fluctuation.

SELF-TEST

1. That is meant by carrying capacity?

2. Describe four biotic and four abiotic factors which cause a population to fluctuate.

QUEST

1. Read: Alberta, A Natural History; Hardy Editor (1968)

NOTE

YOUR FINAL MARK IN THIS UNIT WILL BE A COMPOSITE OF YOUR MARKS ON THE LABORATORY WRITE-UPS AND YOUR MARK ON THE UNIT EXAM

APPENDIX I

The purpose of this lab is twofold: 1) to give the student practical experience in analysing population growth; 2) to show how an abiotic factor affects certain aspects of population growth.

We can analyse the typical growth of a living population and the effects of an abiotic factor on such growth by studying two yeast populations. When conditions are favorable, yeast cells can multiply in a matter of minutes. Such short life cycles result in very rapid increases. Unfavorable conditions will naturally affect this population growth.

Materials

10% corn syrup solution (stock solution)
glass beaker
dry yeast
slides, coverslips
test tubes

Procedures:

Mix a 10% corn syrup solution in a glass beaker and mix thoroughly. Into each of two test tubes, add about 10 ml. of the stock solution. Into each tube add a single grain of active dry yeast (grains should be approximately the same size). Mix the yeast - syrup solution carefully but thoroughly.

Place one drop of material from each tube on separate glass microscope slides and count the total number of cells that each of you see under the high power field. Each partner should take 5 counts from different areas of the slide he is analysing. Average your counts (divide total number in all five counts by five) and record this data as occurring at 'zero' hours.

Place one of the tubes (marked 'cool') in a cool area of the room and the other (marked 'warm') in a warm area of the room.

Continue dual observations as before (note: mix solutions well before analyzing each one) at intervals of approximately 24 hours for about 5 days and record data on a chart like the one following:

Age of Culture in Hours	Warm Culture: No. of cells (per field of view) under high power 1	2	3	4	5	Average	DITTO	Cool Culture: DITTO 1	2	3	4	5	Average

<u>NOTE</u>

If counting becomes difficult because of extremely large numbers of cells after several days, shake mixture to be analyzed thoroughly, dilute 5 drops of this mixture with 50 drops of water. Mix well and analyse as before. Remember you must now multiply your counts here by 10 to obtain an estimated number of cells in a typical high field, because you have diluted your sample solution to 1/10 of its strength before counting. At the end of your study write a report. This will require a preparation of a line graph of your data. Use the age of your culture (in hours) as the units of the horizontal axis and the average number of cells per high power field as the units of the vertical axis.

ANALYSE AND EXPLAIN ALL RESULTS OBTAINED

APPENDIX C

STUDY BEHAVIOUR QUESTIONNAIRE: Form H

STUDY BEHAVIOUR QUESTIONNAIRE: Form H

On the following pages are a number of questions about your usual or habitual study methods.

While researchers have been unable to discover one single best method of study, success is still closely related to your approach to your work. Different people make effective use of widely varying approaches. In order to obtain a comprehensive picture of how you see your own approach, please answer these questions as truthfully as you can. Do not worry about projecting a good image; individual responses will not be identified at any time.

Do not spend too long on any one item. Your first impression is the most valuable for items of this kind.

Use the answer sheet provided. Fill in your name, age, sex and school.

Answer each item according to the following 5-point scale:

1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, <u>OR</u> cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

Answer each question. If you have difficulties about deciding score '3'. Remember, if the statement really applies to the way you operate score high, i.e. '4' or '5'. If it describes the opposite of how you work score low, i.e. '1' or '2'.

Answer Key
1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, OR cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

Questions

1. I think that most people can actually learn better when they are given the facts about a subject instead of having to figure them out by themselves.

2. I try to do all of my assignments as soon as they are assigned.

3. I think it is more important to chose optional subjects in high school that are going to be of direct practical value in my career rather than those that simply interest me.

4. I always try to fit isolated facts into material that I already know.

5. I find a new and unfamiliar approach to an already learned topic confusing and depressing.

6. I usually become increasingly absorbed in my work the more I do.

7. I worry a lot about how I am going to do when I am studying for a test.

8. When I have worked something out for myself and I really believe my view to be sound, I will stick to it if the class or even the teacher clearly disagree with me.

9. If I could find a way to make a teacher think well of me, I would certainly use it.

10. I find that the only way I can learn some subjects (kinds of Material) is to memorize them.

11. I try to work consistently throughout the term and review regularly when the exams are close.

12. I think that subjects with no practical value should be optional in high school.

13. I try to relate what I have learned in one subject to that in another.

14. The continual pressure of work, the drive to meet assignment dead-lines and the constant competition make my life at high school tense and depressing.

15. I have a strong desire to excel in all of my studies.

Answer Key
1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, OR cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

16. I am discouraged by a poor mark on a test and worry about how I will do on the next test.

17. I have to be sure of something in my own mind before I will accept it as being valid or true.

18. I find that it is easier to learn a subject from a teacher I like regardless of his(her) teaching ability.

19. I prefer subjects in which I only have to learn facts to ones which require a lot of reading and understanding of material.

20. After a class or lab I reread my notes to make sure they are legible and that I understand them.

21. I regard my top priority as trying to achieve and maintain an honors standing in my high school courses.

22. In reading new material I often find that I am continually reminded of material I already know and see the latter in a new light.

23. I feel that most tests examine material beyond that which I should reasonably be expected to know.

24. I find most new topics interesting and often spend extra time trying to obtain more information about them.

25. I find that answering most tests takes more time than is allowed for them.

26. While I realize that truth is forever changing as knowledge is increasing, I feel compelled to discover what appears to me to be the truth at this time.

27. I find that the final mark I get on a course depends a lot on the teacher I have.

28. I prefer to learn the facts and details about a topic rather than trying to understand all about it.

29. I keep neat, carefully arranged notes.

30. I regard my high school studies very much as a means to achieving entry into university, technical school or a profession such as nursing.

Answer Key
1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, OR cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

31. When I am reading fresh material, I try to think of what I already know that is related to it and frame questions on this basis that the new material may answer.

32. I feel uncomfortable whenever a teacher asks me a question in class.

33. I would rather take a difficult, interesting course instead of an easy, uninteresting one.

34. I am concerned about how poor results on a test will effect my overall grade in a course.

35. I believe strongly that my main aim in life is to discover my own philosophy and belief system and to act strictly in accordance with it.

36. I take seriously anything that I have been taught, or that is in my textbooks, so that I would change my interpretations only on the strongest evidence.

37. I prefer a teacher that follows the text for a subject rather than one who adds other material.

38. I try to read all suggested references that go with my classes and labs.

39. I will work for top marks in a subject whether or not I care much about the content.

40. When I approach a new piece of reading material, I try to note both the basic factual knowledge it contains and the general theoretical points.

41. It is inevitable that at first one's understanding of a new subject or topic will be confused, but I find this initial confusion very distressing.

42. I find that I have to do enough work on a topic so that I can form my own point of view before I am satisfied.

43. I don't think that a teacher should give a person his mark on a test in front of the whole class.

44. What I make of my life is my own responsibility; I cannot reasonably hold anyone else responsible for whatever happens to me.

Answer Key
1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, OR cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

45. I would question the statements and ideas of my teachers only under special circumstances.

46. I don't spend time on learning things that I know won't be asked on the exams.

47. I summarize suggested readings and include these as part of my notes on a topic.

48. I really enjoy getting a better mark on a test than someone who I know is good at the subject.

49. While I am studying, I often try to think of real life situations in which the material that I am learning would be handy and useful to know.

50. I often fail to complete and hand in written assignments until after the stated deadline.

51. I feel that virtually any topic can be highly interesting once I get into it.

52. I worry that a teacher will try to trick me on a test even though I know the material well.

53. I believe that almost anything is possible if you really work for it.

54. I ask my teachers for extra help whenever I have an assignment or problem which appears to be difficult.

55. I find that the best teachers work from carefully prepared notes and outline major points neatly on the blackboard.

56. I try to anticipate exam topics and questions and use these as study guides.

57. I want top grades in most or all of my courses so that I will be able to select from among the best options open to me when I graduate.

58. I find that discussing a new topic with someone who is familiar with it often helps me understand it better.

59. I think that it is unreasonable for a teacher to expect a high school student to do work outside that assigned by the curriculum in a course

Answer Key
1. This is never or very rarely true of me.
2. This is occasionally true of me.
3. This is true of me about half the time, OR cannot decide.
4. This is frequently true of me.
5. This is always or almost always true of me.

60. I spend a lot of my free time finding out about interesting topics which have been discussed in different classes.

61. Even when I have studied hard for a test, I worry that I may not be able to do well on it.

62. I feel that I might eventually have some power to change things in the world that I see now to be wrong.

63. I prefer to accept what my teachers say even though it sometimes means that I have to change my own ideas.

64. I find that most class discussions are a waste of time because they usually refer to opinions rather than to hard facts.

65. When a test is returned, I go over it carefully correcting all errors and trying to understand why I made the original mistakes.

66. I try to obtain high marks in all of my courses because of the competitive advantage this gives me in following up my future plans.

67. When a teacher makes a point which I don't understand, I try to question him until I can grasp what he is saying.

68. I feel that most teachers expect too much from the average student in their course.

69. I find that studying academic topics can at times be as exciting and gripping as reading a good novel.

70. I worry about what my teacher will think of me if I do poorly on a test.

71. "Inner certainty" is more important to me than modifying my views to fit more easily with what other responsible people think.

72. I am very aware that teachers and textbook writers know a lot more than I do and so I rely on their judgment rather than my own.

73. I keep reviewing important topics until I understand them completely.

74. I make myself study subjects which are not interesting because they are required for my future plans.

75. I find when I study that I read new material twice, once to get the gist of what it is saying and a second time to pick out details.

APPENDIX D

BIOLOGY 20 COGNITIVE TEST

BIOLOGY 20 COGNITIVE TEST

1. The pollen grain is a(an)
   a. haploid spore
   b. sperm cell
   c. megaspore
   d. gametophyte

2. The best evidence that a plant is well adapted to land is that it
   a. possesses vascular tissue and forms spores
   b. reproduces by fission, spores, gamates
   c. possesses vascular tissue and forms seeds
   d. has alternation of generation

3. A difference between complex plants and ferns is that complex plants
   a. do not have sporangia
   b. do not have meiosis occuring in the production of asexual cells
   c. have more than one kind of spore
   d. have the gametophyte as the dominant generation

4. The evolutionary value of sexual reproduction as compared to asexual is
   a. greater uniformity of offspring
   b. greater variability among offspring
   c. that the offspring are more like the parents
   d. a larger number of offspring are produced

5. Respiration withing a cell
   a. occurs only in animals
   b. occurs only in sunlight
   c. releases energy to the organisms
   d. releases oxygen as a waste product

Use the following key to answer questions 6 to 9 inclusive.

   a. Co-ordination
   b. Interdependence
   c. Regeneration
   d. Specialization

6. Flagella move in such a manner in Volvox so that the colony never turns head over heels and always moves towards light. This movement is possible because of ______________________.

7. When cells act as one unit they require less raw material and space than do individual cells.

8. One or more life functions are lost in some cells so that another function can become more acute in these cells.

9. The interior cells of a complex plant receive sugar molecules from the leaves.

10. In the evolution of plant reproduction the great change which occurs in ferns is
    a. sexual reproduction becomes dominant
    b. asexual reproduction disappears
    c. the sporophyte becomes dominant
    d. reduction division appears

11. As cells become more and more specialized for one activity they also become
    a. larger
    b. more numerous
    c. more dependent on other types of cells
    d. more capable of functioning alone

12. In plant alternation of generations the zygote always develops into a
    a. sporophyte
    b. gemetophyte
    c. spore
    d. gamete

13. Which of the following is most likely to be the ancestor of multicellular plants and animals?
    a. flagellated organisms
    b. blue-green algae
    c. green algae
    d. slime molds

14. A seed and a spore differ in that
    a. only the seed is a reproductive structure
    b. the spore is formed by a union of egg and sperm
    c. the seed is diploid, the spore monoploid (haploid)
    d. the spore produces the sporophyte, the seed produces the gametophyte generation

15. Amoeba has no specialized nervous system. It behaves
    a. in a very unco-ordinated manner
    b. without reacting to stimuli
    c. uniformly in an unchanging environment
    d. in a co-ordinated manner and responds to stimuli

16. Essentially the word digestion means
    a. burning food for energy
    b. building up proteins from amino acids
    c. changing organic molecules
    d. breaking large molecules into smaller ones

17. To increase diffusion rate gas exchange systems have
    a. low oxygen tension
    b. large surface areas
    c. rapid osmosis
    d. low surface/volume ratios

18. A sense organ is specialized to receive
    a. many types of stimuli
    b. specific types of stimuli
    c. most changes in the environment
    d. co-ordinated stimuli

19. Organism Reproduction differs from all other functions in an organism because it is not
    a. an energy consuming process
    b. necessary for the individual to live
    c. a normal body function
    d. important to the species to which the animal belongs

20. A student examines microscopically a drop of pond water and discovers unicellular organisms which do not have definite nuclei or chloroplasts. These organisms would correctly be classified as
    a. blue-green algae
    b. Euglena
    c. Amoeba
    d. sarcodina

21. A distinguishing feature of the Sarcodinans is the possession of
    a. irregular shape
    b. microscope hair-like projections
    c. flagella
    d. a cell membrane

22. Nostoc belongs to the Phylum
    a. Schizomycetes
    b. Cyanophyta
    c. Mycophyta
    d. Sarcodina

23. Specialization within living matter is found in organisms that
    a. possess cells that do different jobs or functions
    b. consist of independent cells
    c. are highly complex
    d. carry on all life activities

24. Which of the following is characteristic of invertebrate animals?
    a. lack of necleus in cells
    b. undifferentiated cells
    c. cilia
    d. cell membrane

25. Products of photosynthesis in complex plants are transported to roots for storage by
    a. xylem
    b. phloem
    c. cortex
    d. cambium

26. The structure which can be observed in the cells of a bean plant but not in the cells of a rabbit is the
    a. cell wall
    b. nucleus
    c. vacuole
    d. membrane

27. Different species in the natural state generally
    a. interbreed frequently
    b. interbreed occassionally
    c. interbreed only if they occupy the same niche
    d. do not interbreed at all

28. During which process do molecules move from a region of high concentration to a region of lower concentration?
    a. diffusion
    b. active transport
    c. cyclosis
    d. circulation

Answer questions 29-33 from the following chart.

LIFE CYCLE OF A PLANT

29. Which of the following stages would be diploid?
    a. P, L and M
    b. K, L and M
    c. P, Q and K
    d. M, O and N
    e. P and Q

30. A gamete would be
    a. Q
    b. N
    c. M
    d. K

31. The letter 'P' would be a(an)
    a. zygote
    b. diploid cell
    c. sperm or egg
    d. sporophyte

32. Mitosis may occur between which stages?
    a. K and L
    b. L and M
    c. P and K
    d. N and Q
    e. both a. and b.

33. A zygote would be
    a. P
    b. K
    c. M
    d. N

34. The region of a vertebrates brain in which the sense of sight is interpreted is the
    a. olfactory
    b. optic nerve
    c. cerebrum
    d. medulla

35. Air enters leaves through
    a. stomata
    b. veins
    c. roots
    d. palisade cells
    e. petioles

36. A protozoan capable of producing its own food by photosynthesis is the
    a. <u>Amoeba</u>
    b. <u>Euglena</u>
    c. <u>Paramecium</u>
    d. Hydra
    e. rotifer

37. The front end of an animal is termed
    a. posterior
    b. anterior
    c. ventral
    d. dorsal

38. Most vertebrates have stomachs and intestines which join at the
    a. esophagus
    b. cloaca
    c. mesencery
    d. colon
    e. pylorus

39. The conduction and strengthening tissues of the root lie in the
    a. cortex
    b. cambium
    c. epidermis
    d. central cylinder
    e. endodermis

40. Reproduction in the blue-green algae is always by
    a. mitotic division
    b. meiotic division
    c. conjugation
    d. amitotic division

41. In early spring when leaves are absent and photosynthesis is not taking place the movement of materials in plants is
    a. up in xylem, down in phloem
    b. up in xylem, up in phloem
    c. down in xylem, down in phloem
    d. down in xylem, up in phloem

42. Polar bodies are produced in the process of ____________ formation.
    a. microspore
    b. egg
    c. sperm
    d. daughter cell

APPENDIX E

BIOLOGY 20 COURSE OUTLINE

BIOLOGY 20 COURSE OUTLINE

The major objective of Biology 20 is to allow the student the opportunity to study the diversity of living things by examining closely the representatives from different groups of organisms. Unipacs will be issued and they will serve as a guide to student learning. Unit objectives provide the student specific goals to attain and the path by which these endproducts may be attained is through the learning activities.

The areas of study and the approximate time spent on each one are listed below.

1. Evolution (10 Days)

2. Protista and Monera (7 Days)

3. Simple Plants (8 Days)
   One of the following units MUST be completed.
   - Algae
   - Fungi and Lichens
   - Mosses and Liverworts

4. Ferns and Horsetails (5 Days)

5. Complex Plants (10 Days)
   One of the following units must be completed
   - Gymnosperms
     or
   - Angiosperms

6. Simple Animals (10 Days)
   One of:
   - Flatworms
   - Segmented Worms
   - Sea Cucumber
   - Molluscs (clam)
   - Grasshopper
   - Crayfish
   - Squid

7. Complex Animals (10 Days)
   One of:
   - Fish
   - Frog
   - Pig

8. Organism Diversity (6 Days)

9. Final exam May 19th

10. <u>Project - outdoor</u> (20 Days)

One of:

- Insect Collecting
- Soil Analysis
- Quadrat
- Transect
- Vegetative Productivity

Resource materials available to the student may be checked out from the resource center after payment of the biology resource materials fee. For details on this procedure, see handout entitled "McNally Biology Resource Center".

APPENDIX F

SUMMARY OF ANALYSIS OF VARIANCE
INVOLVING R AND Q APTITUDES
WHICH DID NOT SHOW SIGNIFICANT INTERACTIONS

SUMMARY OF ANALYSIS OF VARIANCE

INVOLVING R AND Q APTITUDES

WHICH DID NOT SHOW SIGNIFICANT INTERACTIONS

For each summary, the A effect corresponds to schools; the B to SCAT quantitative ability; and the C to the specific R or Q aptitude.

RI-FACT-ROTE

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.735	
B	2	267.06	13.302	< .001
AB	2	4.19	0.209	
C	2	43.40	2.162	
AC	2	13.36	0.665	
BC	4	10.52	0.524	
ABC	4	24.93	1.242	
WITHIN CELL	90	20.08		

R2-STUDY SKILLS AND ORGANIZATION

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.759	
B	2	267.06	13.385	<.001
AB	2	4.19	0.210	
C	2	16.73	0.839	
AC	2	4.53	0.227	
BC	4	39.02	1.956	
ABC	4	17.01	0.853	
WITHIN CELL	90	19.95		

R3-INSTRUMENTAL MOTIVATION

SOURCE OF VIARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.521	
B	2	267.06	12.538	<.001
AB	2	4.19	0.197	
C	2	6.84	0.321	
AC	2	21.58	1.013	
BC	4	17.80	0.836	
ABC	4	4.32	0.203	
WITHIN CELL	90	21.30		

R4-MEANING ASSIMILATION

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.496	
B	2	267.06	12.447	<.001
AB	2	4.19	0.195	
C	2	1.84	0.086	
AC	2	21.58	1.006	
BC	4	7.97	0.371	
ABC	4	13.15	0.613	
WITHIN CELL	90	21.46		

R5-ACADEMIC NEUROTICISM

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.832	
B	2	267.06	13.646	<.001
AB	2	4.19	0.214	
C	2	39.70	2.029	
AC	2	19.44	0.994	
BC	4	44.37	2.267	
ABC	4	1.31	0.067	
WITHIN CELL	90	19.57		

R6-ACADEMIC MOTIVATION

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.755	
B	2	267.06	13.371	< .001
AB	2	4.19	0.210	
C	2	50.45	2.526	
AC	2	7.69	0.385	
BC	4	6.37	0.319	
ABC	4	30.72	1.538	
WITHIN CELL	90	19.97		

R7-TEST ANXIETY

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.465	
B	2	267.06	12.339	< .001
AB	2	4.19	0.194	
C	2	11.37	0.525	
AC	2	22.33	1.032	
BC	4	8.12	0.375	
ABC	4	3.61	0.167	
WITHIN CELL	90	21.64		

[illegible]

Q1-HIGH PERFORMANCE STRATEGY

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.796	
B	2	267.06	13.516	< .001
AB	2	4.19	0.212	
C	2	47.90	2.424	
AC	2	35.58	1.801	
BC	4	9.15	0.464	
ABC	4	20.11	1.018	
WITHIN CELL	90	19.76		

Q2-LOW PERFORMANCE STRATEGY

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.464	
B	2	267.06	12.337	< .001
AB	2	4.19	0.194	
C	2	21.84	1.009	
AC	2	7.53	0.348	
BC	4	3.55	0.164	
ABC	4	10.26	0.474	
WITHIN CELL	90	21.65		

Q3-EXPERIMENTAL SCHOOL STRATEGY

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
A	1	75.00	3.568	
B	2	267.06	12.704	< .001
AB	2	4.19	0.200	
C	2	14.56	0.693	
AC	2	9.03	0.429	
BC	4	4.27	0.203	
ABC	4	26.51	1.261	
WITHIN CELL	90	21.02		